Saskatchewan Power Resources Commission.

Report.

1928

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OF

Saskatchewan Power Resources Commission

Appointed by Order-in-Council
Dated January 7th, 1927

REGINA:
J. W. REID, KING'S PRINTER
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TO THE HONOURABLE JAMES G. GARDINER,
President of the Executive Council,
Regina.

SIR,—

By an Order-in-Council dated January 7, 1927, a Commission was appointed to enquire into and report upon the economic practicability of generating power at central power plants and water power sites in the province, and the distribution of the same throughout the province. A copy of the Order-in-Council is attached hereto, as appendix No. 1. By this Order-in-Council the Commission was instructed to deal with certain twelve questions in particular without restricting the generality of the above mentioned subject of enquiry.

The Commission prepared and forwarded to all the cities, towns and villages (excepting the very smallest of the province) a questionnaire covering in detail the particulars of their investment in light and power plants and distribution systems, together with a description of the installation and details of the operating costs and output. Approximately 260 questionnaires were sent out. The response to this questionnaire was satisfactory, excepting in a few instances of privately owned plants. After repeated enquiries, further replies were received, but there are a few small installations in respect to which no particulars have been received. These exceptions will in no way affect the situation.

The data contained in the answers to the questionnaire has been summarised as set out in appendix No. 2, schedules numbers 1 to 4 which are attached hereto.

A summary of these schedules indicates that there has been invested in power plants, equipment and distribution systems throughout the province the sum of $9,058,076, and that against this investment there is a debenture indebtedness as at December 31, 1926, of $6,224,707. The present value of the plant and equipment, according to replies received, is estimated at $4,287,926 and the present value of the distribution systems is estimated at $2,312,328.

The summary further indicates that the total capacity of the power plants in the province is 43,757 K.W., and that there are 712 miles of distribution pole lines. The total energy generated in these plants during the year 1926 was 69,553,844 K.W. hours sold to 44,471 consumers.

The cost of producing and distributing this energy for the year 1926, including the fixed charges on the systems, was $2,194,221, and the revenue received was $2,801,516.

In addition to the returns filed with the Commission it is estimated that there have been installed in the province some 7,000 individual lighting plants which represent an investment of approximately $4,000,000, and a production of from 150 to 200 K.W. hours per year per unit.

Two charts have been prepared and are attached hereto as appendices Numbers 3 and 4. The first indicates the average consumption per consumer in terms of the cost of the current, and the second indicates the average consumption per head of population in terms of the cost of the current. These curves indicate that where the costs of current are high the consumption per consumer and per head of population is comparatively low, and as the costs are reduced consumption very materially increases, from which may be deduced the assumption that the provision of a supply of cheaper electric energy, particularly in the smaller centers, will result in a very large increase in the use of such energy.

A map has been prepared and is attached hereto as appendix No. 5 which shows the population of the urban centers of the province.

The Commission arranged for and held public meetings at the following centers: Regina, Saskatoon, Prince Albert, North Battleford, Moose Jaw, Swift Current, Estevan and Yorkton.

Due notice of these meetings was published in the newspapers, and by correspondence with the responsible municipal authorities. At a number of these sittings representatives from other places were present. The interest shown at these sessions appeared to be confined to the officials in charge of the local systems, and other members of the public were substantially in evidence in only a few instances. The Commission had an opportunity of discussing with these officials their local situation intimately, and of enlarging upon the information set out in the questionnaire.

On the occasion of the hearing at Prince Albert a visit was made to the hydro-electric development at La Colle Falls commenced some years ago by the City of Prince Albert and abandoned later. At Estevan the Commission had the opportunity of visiting a number of the coal mines in the vicinity, and of discussing with those in charge the question of coal costs and the prospects of developing an electric power load in connection with their operations. A visit was also made to the carbonisation plant at Bienfait.

The Commission was impressed with the fact that those in charge of the electric power systems in these centers were fully acquainted with all the essentials connected with their operation, and were attaining quite successful results under the circumstances of the demands made on the systems.

Shortly after the Commission was appointed there became evident throughout the province activities on the part of certain individuals and companies seeking franchises to sell electric power to municipalities within the province, and proposing to link up a number of these municipalities in a general scheme of power distribution. While it was evident to the Commission that this action might considerably complicate and involve the programme with which the Commission had to deal, and might create rights which would be detrimental to the establishment of a systematic power distribution scheme, the Commission concluded that the matter was not within its jurisdiction, and at the same time so advised the Minister. The Commission did, however, discuss the situation at some length with the Attorney General's Department with a view to arriving at a considered statement of the legal position which these activities might involve.

The Commission proposed to the Minister of the Department in charge, the engagement of Consulting Engineers, and having secured his consent, a number of available Consulting Firms were considered and eventually Messrs. Sullivan, Kipp and Chace, Consulting Engineers, of Winnipeg, were retained. A certain number of the questions outlined in the Order-in-Council were referred to the Consulting Engineers for a full report. The instructions to the Consulting Engineers are set out in the preface of their report, a copy of which is submitted herewith.

Upon the request of the Commission, Hon. T. C. Davis had a conference with the Department of the Interior at Ottawa, and received from the Minister in charge assurance of the assistance of the department in connection with supplying existing data on water powers in Saskatchewan, and making such further investigations as might be deemed necessary in this connection. The Commission had an opportunity of discussing the situation with Mr. C. H. Atwood and Mr. J. H. Tempest, western officers of the department, and were again assured of any assistance which they might be able to afford. Much information was supplied to the Commission, and also to the Consulting Engineers, by the officials of the Department of the Interior, and their courtesy is hereby acknowledged.

The Commission was afforded opportunities from time to time of discussing with Mr. T. M. Molloy, Deputy Minister of Railways, Labour and Industries, the developments in the Souris valley coal fields, and the progress being made in connection with the carbonization of the fuel. Mr. Hastings, of Mr. Molloy's Department, reported to the Commission on the coal fields of Saskatchewan, and in particular, on the Lake-of-the-Rivers coal fields, and assisted in the preparation of information respecting the development of rural electrification.

Mr. R. N. Blackburn, M.E.I.C., Chief Mechanical Superintendent, of the Department of Public Works, was, by the Order-in-Council, appointed Secretary to the Commission, and throughout the enquiry has acted in this capacity, and as Engineer has prepared

much of the data connected with the enquiry, and a large number of charts and graphs, some of which are included in the report, and will be discussed later.

We wish to make special mention of the assistance accorded the Commission at all times by the Power Superintendents of the larger centers of the province, who have submitted much valuable information in connection with the enquiry.

Saskatchewan is an agricultural province with few cities widely scattered, and a multiplicity of villages and hamlets located at fairly regular intervals along the railroads that traverse the province. The cities have a record of rapid growth in population, and a still more rapid growth in the consumption of electric energy. The consumption per head of population of the four largest cities in the province as compared with twelve large cities in Ontario has been in the proportion of about five to seven, although the average cost to the consumer in Saskatchewan cities has been nearly three times that in the Ontario cities. The cost of electric energy to the consumer in the Saskatchewan cities is considerably less than the average cost in the United States, and the consumption per capita has been much higher. The comparatively generous use of electric energy in the larger cities of this province when contrasted with that in large cities in Ontario more favorably situated as to cost, may be explained on the grounds that in the older communities other services are available in place of electricity, also that our western cities are newer and have grown up with the electrical development. Within the province, however, the rule holds good, that in the larger communities where the cost to the consumer is low the consumption is relatively much higher than in the smaller communities where the cost of current is greater, and there is no question but that the use of electricity will be greatly increased, particularly in these smaller centers, when cheaper energy is supplied. We are of opinion that the records of costs of production of electric energy in the larger cities of the province represent results which may be favourably compared with results attained anywhere where a similar source of power is used, and that generally speaking the only instances where lower costs of electric energy are available are those in which water power has been developed on a large scale.

It became evident to the Commission at the outset that the water power possibilities of the province should be investigated, and this question has been dealt with in detail in the report of the Consulting Engineers. While further reference to this question will be made later, it may now be stated that the report shows that there is no immediate possibility of an economic hydro-electric power development in the province. The water powers in the far north of the province are too distant to be of immediate interest, except to local mining industries and other developments which may follow in the vicinity. The only water power available in the province, within reasonable reach of the settled area, is on the Saskatchewan River, and for the purposes of this report the development of power at a site below the forks of the North and South

branches has been considered. The cost to develop the power is high. The variation in the flow of the river is as much as one hundred times greater in the summer, when the demand is light, than in the winter, when the demand is heavy. When the summer load on a large development scheme in the province reaches 50,000 K.W. or over, it might be economically feasible to develop power at the Forks but such a scheme would have to show a cost of production not greater than the fuel cost in a steam station, and this, in our opinion, will not be brought about before the year 1942.

The next consideration which presented itself to the Commission was whether the establishment of a large power plant at one or more centers in the province, and the erection of transmission lines from the power station or stations to the larger cities would promise a reduction in the costs of electric energy to these large consumers. Consideration of this problem has been given at length in the report of the Consulting Engineers. The larger cities consume over 80 per cent. of the electric energy produced in the province, and any scheme of development must naturally be closely connected with this load. The cities are separated by long distances, and while a power station might be erected which would generate power in large quantities at less cost than the existing city plants are capable of, the cost of transmission lines and transformer equipment of the large capacity required to deliver the current to these cities, together with the losses in transmission, have led us to the conclusion that such installation cannot hope to compete with the results which will be possible in the cities themselves for a number of years to come. When, however, the loads in the cities have increased to much larger proportions than at present, and when the intervening territory will absorb considerably larger quantities of energy than at the present time, we believe there will be room for such an installation.

As already stated, excellent results are being obtained in the principal cities in the cost of production of electrical energy, and we are assured that with the growth of demand the plants in question may be improved and enlarged, and will be capable of even better results. These plants have been designed with a capacity to supply the local needs of the community, and on account of the variation in the loads of the plants at different times of the year and different hours of the day, the capacity of the plants is much greater than the average demands on the plants, and it would appear that any additional load which can be obtained to help bear the overhead expenses will result in a reduction in the average costs of production. We have given considerable study to this situation in connection with the three cities, Regina, Saskatoon and Moose Jaw. These three cities on account of their location are within reasonable distance of the bulk of urban population in the province, and we believe that the use of the power stations located in these centers, as stations for the supply of power to be distributed to the surrounding territory by means of comparatively low tension and low cost transmission lines, presents a combination for the development of power service which will make power available at

reasonable rates to a large part of the province, and which will be justifiable on the ground of economy over the alternative proposal to establish one or more large central plants connected to the cities and towns by a costly transmission line. We propose to discuss this matter more fully later on in the report.

While these three cities have been mentioned as an example, we may point out here that there are some parts of the province which are not within reasonable distance of these centers, and possibly these more remote districts might preferably be served from a system or systems similarly organised within the districts in question.

Referring to the questions submitted to us for investigation and report, Question No. 1 reads as follows: "As to the economic "practicability of the construction of central power plants on the "lignite coal fields of Southern Saskatchewan."

The interpretation of the term "central power plant" is taken to mean a large power plant from which electric energy will be transmitted to serve a district of considerable extent tributary to the center.

We have elsewhere referred to the load conditions in the province and pointed out that the three principal city power plants produce 80 per cent of the total power generated in the province. The consideration of a plant located at Roche Percee has been discussed at length in the report of the Consulting Engineers. A power plant located at Lake-of-the-Rivers has also been considered.

The large station which might be considered as located at Roche Percee would, in any event, only be justified if it could serve Regina which is the largest load in the province nearest situated to this location. The Regina municipal power plant is already erected at a large cost and the fixed charges of this plant must continue to be met. The Regina plant is modern in every way and it can be assumed that the same relative efficiency in operation might be expected at Regina as compared to a location on the coal field.

The first consideration then which presents itself is the cost involved in transmitting energy from the coal field to Regina. In the one case it might be transmitted by a power line or, in the alternative, the coal could be freighted to Regina and the power generated from it locally. Mr. R. N. Blackburn has prepared a report which discusses the relative costs of transmitting power electrically from Estevan to Regina and the cost of freighting the equivalent coal, a copy of this is attached hereto as Appendix No. 6. In general this report indicates that the cost of electric transmission is somewhat more than the cost of freighting the equivalent coal. When it is considered that a certain additional expenditure would require to be met at Regina to keep the plant ready as a stand-by in case of interruption of service over the transmission line and further when it is considered that the new plant at the coal field would duplicate the fixed charges on the

Regina plant it is evident that for the present and for some considerable time to come there is no economy to be derived from the establishment of a large plant on the coal field at a point so far distant from the center of the load. When the load is increased to an amount sufficient to warrant a transmission line of much larger capacity the cost of the transmission per unit of energy delivered can be materially reduced and by this time there may be much more definite grounds for consideration of a plant so located but some years will elapse before this, during which time the existing plants at the larger centers will continue to be at their present state of high efficiency

In the report of the Consulting Engineers considerable reference is made to the operating conditions at such a plant at the coal fields and it is pointed out that an adequate supply of water for condensing purposes is of vital importance and some question has been raised as to the availability of such a supply

In the Consulting Engineers report the station at Roche Percee is studied as a central course of energy for supplying a system connecting Regina Moose Jaw and Saskatoon and intervening points and much interesting data as to the cost of construction and the cost of operation appears in the report. We propose to discuss this general situation later on

With respect to the suggested plant at Lake-of the-Rivers as a source of supply to Moose Jaw and Regina the deductions in Mr Black arn's report, comparing freight costs with transmission costs would not represent altogether the same conclusion but as already pointed out the fixed charges on the two plants at Regina and Moose Jaw must continue to be carried in addition to those at the central plant. The extra fixed charges which would result from the erection of a central plant would be much more than any saving which could result by transmitting power rather than freighting the coal from these coal fields. We have in this connection received a report from W H Hastings discussing the coal fields of Saskatchewan a copy of which is attached hereto as Appendix No 7. In this report and in the report of the Consulting Engineers it is pointed out that there is no proven supply of coal in quantities sufficient for a central plant located at Lake-of-the-Rivers and that before any plans are adopted with respect to its location at this point the availability of such a supply should be established

Question No 3 As to whether it would be preferable in the alternative or in addition to No 1 to locate central power plants at other suitable points in the province with a view to the ultimate interconnection of these various central systems

In the report of the Consulting Engineers in Tables Nos. 11 and 12 are shown particulars of the 1926 demand and production experienced in the principal centers of population situated along the line extending in the general direction from Estevan to Saskatoon and from Saskatoon to the Battlefords from Saskatoon to Prince Albert from Regina to Moose Jaw and from Regina to Kamsack

These tables also project into 1930 and 1935 estimated conditions based on an assumption of an increase in demand of 10 per cent. per annum We believe this assumption is a reasonable one, particularly in view of the experience which has been reported from Regina and Saskatoon covering a number of past years The actual consumptions at Regina and Saskatoon are shown, in the first case since 1907 to date and in the second case since 1913 to date or the curves contained in the Consulting Engineers report, which indicate that the growth has been in excess of 10 per cent per year This assumption is supported by the further consideration that the cost of production in the future should decrease, and this decrease in production cost will induce consumption at an increased rate

An examination of Table 11 clearly shows that the influence of the three cities in the system is all important In the forecasted loads of 1935 these three cities have a load of over 85 per cent of the total of those places listed We feel confident in stating that the loads of these three places represent over 80 per cent of the total requirements of the province.

In these three cities the power stations have been developed as follows

	Generator Capacity	Peak Load 1926	Output 1926	Peak Load 1927
Regina	16,000 K W	8,000 K W	24,520,650 K W H	8,100
Moose Jaw	11,000 K W	3,925 K W	12,752,312 K W H.	4,200
Saskatoon	10,200 K W	6,[illegible]00 K W	19,256,980 K W H	6,900

The cost of generating electricity including all fixed charges, were as follows, for 1926

Regina	1.31 cents per K.W.H
Moose Jaw	1.84 cents per K W H
Saskatoon	1.75 cents per K W H.

The average cost of the three is 1.65 cents per K.W H.

NOTE —In computing the above costs the total fixed charges have been apportioned as follows

Regina	60% to generation, 40% to distribution
Moose Jaw	60% to generation, 40% to distribution
Saskatoon	54.5% to generation, 45.5% to distribution

The Consulting Engineers in their report discuss central stations at Roche Percee, Lake-of-the-Rivers and at Elbow, the first two locations being on the Saskatchewan lignite fields, and the third station at Elbow being centrally located as far as the power load is concerned, and with further advantages as to water supply and the accessibility to a further source of fuel from the west. In their examination of these three sites it was shown that the capital expenditure is less at Elbow, and that the efficiency of the three systems is approximately the same Taking the Elbow location as a basis for discussion, we are setting out below a tabulation of the items of cost set out in the Consulting Engineers' report These figures are taken at the estimated annual cost in the year 1935 when there will be delivered to these three centers 150,000,000 K W hours of energy

It will be noted from this calculation that the average cost per K W H with the single circuit transmission line is 1 09c and with a double circuit line 1 12.c We have assumed that the allowance for stand-by cost at city plants is not sufficient and have amended these unit costs to 1 112c for single circuit line and 1 144c for a double circuit line

A further reference to the table below shows the high proportion of cost in this system represented by the continuing fixed charges at the city plants and the cost of transmission line and transformer stations. These items added together represent a unit cost of .487c for single circuit and .526c for double circuit line per K W H which represents nearly one-half the total cost

With the present efficiency at the Regina plant and the efficiencies which will be possible at the Moose Jaw and Saskatoon plants when further expenditures are made the central plant cannot promise such a reduction in operating costs at the plant itself to compensate for this high item of cost represented by transmission lines, transformer stations and city continuing charges

The following table does not include the extensions to the Battlefords, Prince Albert or Kamsack

Elbow Station

Single Circuit Transmission Line

Page	Capital Invested $5.645,000.00	
76	Fixed charges plant	$304,100 00
71	City continuing fixed charges	313,102 00
93	Transmission line	158,138 00
94	Transformer stations	124 480 00
94	City sundries	25,000 00
94	City stand-by	73,100 00
94	Administration	20,000 00
76	Fuel on 150,000,000 at .386c	579,000 00
91	Line and transformer loss at 6¼%.	37,635 00
		$1.634,555.00

Cost per K W H = 1.0897c on a basis of 150,000,000 K W H

Double Circuit Transmission Line

Page	Capital Invested $6,237.825.00	
76	Fixed charges plant	$304.100 00
71	City continuing fixed charges	313 102 00
93	Transmission line	205,626 00
94	Transformer stations	124.480 00
94	City sundries	25,000 00
94	City stand-by charges	73.100 00
94	Administration	20,000 00
76	Fuel on 150,000,000 K.W.H.	579,000 00
91	Transformer and line losses 6¼%	37.635 00
		$1,682,043 00

Cost per K W H. = 1 121c on a basis of 150,000,000 K.W H.

94 Note $34,000 should be added to stand-by charges

Rate per 150,000,000 K W H = 1 112 single circuit
= 1 144 double circuit

On page 170 of the Consulting Engineers' report it is estimated that the average cost of energy generated at a central steam station and delivered at city low tension bus-bars for distribution to customers would be 1.45 cents per K.W.H. in 1930 and 1.17 cents per K.W.H. in 1935. This estimate is on a basis of a general system from a central steam plant with a high capacity transmission line connected to the cities. The estimate is a conservative one and the unit costs predicted are felt to be adequate to support the system from the outset.

A very material part of the capital cost of the system is represented by the steel tower transmission line and transformers, and the cost per unit of energy delivered for the maintenance and fixed charges of this transmission line during the first few years of its use would be relatively high. In view of this fact and the further consideration that the fixed charges would still remain to be met by the three city plants in addition to the fixed charges of the proposed central plant, it became apparent that the central plant scheme would not promise immediate betterment of costs.

At a conference with the electrical engineers of the three cities the situation was discussed at length and they were asked to supply the Commission with estimates covering the further capital expenditure which would be required at their respective plants to supply the load requirements estimated for the year 1935, together with an estimate of the unit cost of production in the same year.

Mr. E. W. Bull, Superintendent of the Regina Light and Power Department, pointed out that the present Regina station had been erected in 1913 at a period of low costs to meet the requirements of the future, and that the cost of additional equipment needed in this plant to bring its capacity up to the required capacity for 1935 was estimated at $400,000.00, principally accounted for by the addition of one 10,000 K.W. turbine and the converting of a battery of boilers to increase capacity and equip for burning powdered fuel. He estimated the total cost of generation per K.W.H. in 1935 at .8128 cents. The Regina plant at the present time and particularly by 1935 will have much lower capital costs to meet than the other two city plants. This is accounted for by the above mentioned policy adopted in 1913 and by the fact that very considerable contributions have been made to the plant from revenue rather than from borrowed capital.

Mr. J. D. Peters, the Superintendent of the Light and Power Department at Moose Jaw, submitted an estimate which provided for an additional investment of $250,000 required to equip the Moose Jaw plant to meet the load conditions predicted for 1935. This expenditure provided in the main for one 5,000 K.W. steam turbine and 1,500 H.P. additional boiler capacity equipped for burning powdered fuel. Mr. Peters estimated his total cost of generation per K.W.H. in 1935 at 1.039 cents.

Mr. J. R. Cowley, Superintendent of Light and Power Department, Saskatoon, submitted an estimate of $1,767,500 to re-build their power plant of sufficient capacity to take care of the 1935

predicted load This made provision for equipment for one 7 500 K W station immediately and an additional 10,000 K W steam generator with two 1 000 H P boilers and accessory equipment later on Mr Cowley estimated the total cost of generation per K W H in 1935 at 1 067 cents

The costs of generation, just referred to, may be divided as indicated in the following table

Cents per K W H

	Fuel	Wages	Maintenance	Supplies and Oil	Water	Fixed charges	Total
Regina	44	10	045	007	0015	2193	8128
Moose Jaw	55	108	131	0231		227	1 039
Saskatoon	38	110	05	008	001	5.8	1 067

These individual reports supply in detail particulars of the estimated costs in 1935 We have given careful consideration to these estimates and believe that they are substantially correct and reasonably represent what may be expected with the loads projected

In view of these projected costs being below that estimated in the report of the Consulting Engineers which dealt with the cost of a central station with the necessary transmission lines, transformer stations and the fixed charges of the three cities, together with stand-by and depreciation charges, all of which were included in the cost of 1 17 cents, it would seem advisable for the present at least, to continue the operation of the three city plants and to add to them where required such units as are or may become necessary until the central station meeting or lessening these rates can be built and to use these plants as central stations with power lines radiating out from them to wherever it is economically feasible These stations, particularly those at Regina and Saskatoon, can be extended to very much larger proportions than the load conditions will indicate as necessary for many years to come

These three central stations with radiating lines will supply, because of their situation a very large proportion of the urban population of the province There are certain sections, however, in the west, east and south of the province which would not immediately be tributary to these stations and we are of opinion that secondary central stations could, if not immediately, at least in a very few years be established at such points as Swift Current, Unity or Kerrobert, Yorkton Melfort, Weyburn or Estevan It can also be foreseen that by the time the city central stations with their radiating lines become loaded and by the time that renewal of pole lines or power house equipment, etc becomes necessary, the central power station as outlined in the Consulting Engineers' report may become an economic necessity The central power station could then be built with an assured load, also a more permanent type of transmission line with higher voltage and greater carrying capacity could be built consolidating the lines

With the construction or the establishment of such a system supplied by a number of central stations with radiating lines, there at once arises the question of the provision which should be made to co-ordinate the system. It is evident that it is only by concerted action that some such system could be made available for the use of the extended limits of the province which have been described. If the development of such a system is left to the initiative of the cities or of private interests working from different points there will be a clashing of interests and duplication of expense in many ways and the desired result would not be obtained as readily or as soon; also the costs would be somewhat higher than if the direction of the whole scheme were undertaken by some central authority.

The erection of a central authority at once suggests three alternatives. One, an inter-city pool which would be empowered to extend and sell to other municipalities. Two, a privately owned company which would either buy these central plants and extend therefrom, or purchase power from these plants for such extensions. Three, the Province of Saskatchewan could either take over and operate the city plants and make the necessary extensions, or purchase power from the central plants to supply the necessary extensions.

In our opinion, of these alternatives there are many reasons which point to that wherein the province is suggested as taking over the plants and operating the same, as being the alternative which will prove ultimately of the greatest advantage to the people of Saskatchewan. The three cities should derive benefits from the point of view that their power stations will be enlarged to supply greater loads than they are likely of themselves to produce, under practically the same conditions of management and costs of production as would obtain if they continue to operate the plants themselves. The supply of electric energy at reasonable rates which would be made possible by such a scheme to a large territory tributary to these centers will of itself create a condition of living in this territory which will indirectly accrue to the benefit of the large centers with which the tributary territory is in continuous communication. The funds for capital expenditures necessary can also be procured by the province at a cheaper rate than by the individual municipalities. This is an important item of cost in power plant economics. The credit of the municipalities would be also relieved of the sums necessary to invest in power plant installation.

A recent amendment to existing legislation relieves the borrowing power limitations of the municipality in respect of future debenture issues for light and power expenditures, but notwithstanding this, borrowings made on this account, while not directly affecting the borrowing power of the municipalities would have an effect on their credit. An unification of the systems would also make possible a reduction in costs owing to greater purchasing power and to the interchange of existing equipment from one plant to another in emergent cases. A transmission line between

Regina and Moose Jaw would have the effect of postponing capital expenditures which if the plants were not connected would have to be made. The radiating systems from the north and from the south would meet at some point, which would make possible assistance from one or the other of these plants in emergent cases for temporary supply of an amount of energy needed for essential public services, and thus a greater continuity would be guaranteed throughout the system.

As contrasted with private ownership, the province could surely secure funds for the erection and operation of such a system on a cheaper basis than private interests, and the element of private gain which necessarily must be provided to private ownership need not be figured in a publicly owned system. While much has been said in the United States in criticism of public ownership, it is fair to point out that private ownership is strongly entrenched in the United States and is responsible for much propaganda on its own behalf. On the other hand public ownership has been successful, particularly in the western provinces of Canada, and if the system of public ownership continues to be operated on the same business principles as in the past this system will continue to meet with public approval. We do not consider that we need to support this statement at any great length. There is no doubt that the municipal light and power utilities in western Canada are affording service to their customers at rates which are acknowledged by authorities throughout the continent as being very favourable rates indeed.

A reference to Appendix No. 2 where particulars of the costs of producing electric energy in many of the smaller centers are given, shows at once a great disparity in the costs of production between the large city plants and the small town plants. As is referred to elsewhere this is not necessarily a result of incompetence in management. On account of the limited load it serves the investment in a small plant and its cost of operation are very high as compared to these costs in the larger plants where the loads are so much greater. In many instances the costs are so high in the smaller plants that the service can only be given for a limited number of hours per day. A central system would afford a 24 hour service throughout and the ultimate cost to the small community would be but a fraction of their present costs. Later on we will submit estimates of the costs of delivering energy over a system from Regina to Moose Jaw and from Saskatoon to the Battlefords and to Prince Albert. The present total costs of production at Radisson and Rosthern located on these lines are 18.6 cents and 16.9 cents respectively. We have estimated in the system referred to that power can be transmitted to Prince Albert and the Battlefords and intervening points at approximately 2½ cents per K.W.H. in the case of the Prince Albert branch and at approximately 3½ cents per K.W.H. in the case of the Battlefords branch. A further reference to Appendix No. 2 shows that the distribution costs in these smaller places are only a small part of the total cost. They would not in any case be greater than the costs of delivering the power in bulk

from the general system just referred to and by adding these two costs together it is very evident that these smaller communities can be afforded a service at rates altogether outside the range of possibility from their own plants.

In this connection the coals at the Battlefords and at Prince Albert have an influence on the low costs and it cannot be assumed that the same results could be at once obtained on a line radiating from a central plant and serving only a number of smaller places. In the latter instance however the power lines would be less expensive and would make possible very material reductions in the present costs of production. We have as tried as a trial instance a line from Regina to Wolseley serving a number of small centers based on assumed use of 100 K.W. hours per annum per head of population in the places which would be served en route but without the influence of a large load at the end of the line. In the case assumed the average cost would not exceed 6 cents per K.W.H. including the cost of production at Regina, fixed charges and maintenance on transmission line, line losses and transformer costs. The present cost of production as reported from Indian Head, the largest town along the line, is 12 cents per K.W.H.

This comparison of costs does not take into consideration that the towns will have to continue to pay the fixed charges on their plants during the life of the plants. We have estimated that the fixed charges at Indian Head approximate 1.5 cents per K.W.H. on the basis of our comparison. It is evident that with the reduction in the cost to the consumer and with a 24 hour service the consumption of energy at these places would materially increase, which would again make possible a reduction in cost, inasmuch as the largest item of costs is represented by the transmission and transformation costs, which would thus be spread over a greater load. The same reasoning can be applied to other radiating lines throughout the sphere of influence of the three central plants.

We have elsewhere made reference to the development of farm loads where the transmission lines are within reasonable reach of the farmer. While the present individual plants which are installed in great numbers throughout the province have rendered good service to the purchasers these plants can in no way be considered as competitors to a transmission line system. It has been estimated that the cost per K.W.H. produced in these small individual plants is not usually less than 50 cents, except in isolated cases. This appears very high but when the investment, depreciation and costs of operation are taken into consideration it will be found to be under rather than over the mark.

In discussing the farm service from transmission lines it is assumed that the farmers will make somewhat extensive use of the current and not use it alone for lighting purposes in the home. It is safe to say that this service can be supplied farms within a reasonably short distance of pole lines at a maximum of 10 cents per K.W.H. decreasing with the extended use of the service. The cost of serving rural consumers at a considerable distance from

the existing network of transmission lines will be necessarily higher. For full particulars of the problem of "Rural Electrification" we refer you to Appendix No. 9.

Returning to the discussion of a general system using the three large cities as a basis, we have worked out as an example a skeleton plan connecting Regina and Moose Jaw by transmission line and connecting Saskatoon with the Battlefords and Prince Albert. The Saskatoon plant, as already indicated, will require immediately to be greatly enlarged and in our estimate we have provided for an additional unit in 1934 at Saskatoon over and above the extensions estimated as necessary by the Superintendent of the Saskatoon plant. We have also provided for a further 10,000 K.W. unit in the Regina plant in 1934; this is in addition to the estimated extension provided for in the estimate of Mr. Bull, the Regina Superintendent. The estimates are based on predicted consumptions at the principal points mentioned, as set out in the following table.

ESTIMATED CONSUMPTION—YEARS 1930–1935

Year	1930	1931	1932	1933	1934	1935
Regina	48,300,000	42,800,000	47,000,000	51,800,000	57,000,000	62,600,000
Moose Jaw	8,700,000	20,600,000	22,600,000	24,900,000	27,400,000	30,100,000
Total Southern System	57,000,000	63,400,000	69,600,000	76,700,000	84,400,000	92,700,000
Saskatoon	29,000,000	3[illegible],900,000	35,[illegible]00,000	38,600,000	42,500,000	46,700,000
Prince Albert	1,900,000	5,400,000	5,900,000	6,500,000	7,200,000	7,900,000
North Battleford	2,[illegible]10,000	2,320,000	2,550,000	2,810,000	3,090,000	3,400,000
Total Northern System	36,010,000	39,620,000	43,550,000	47,910,000	52,790,000	58,000,000
Total both Systems	93,010,000	103,020,000	113,150,000	124,6[illegible]0,000	137,[illegible]90,000	150,700,000

We have assumed certain amounts as the purchase price of the plants at these centers, as set out in the tables of capital expenditures, which immediately follow It may be pointed out that these purchase prices are assumed with some reference to the present debenture indebtedness and present book values of the plants in question, but we have no assurance that these amounts would be acceptable as a basis of negotiation with the authorities in these centers. We would point out, however, that these purchase prices should be sufficient to take care of the fixed charges on these plants throughout the lifetime of the debenture indebtedness, and would at the same time leave to the municipalities for diversions to other uses funds already on hand to the credit of depreciation accounts. It may also be pointed out that should these purchase prices be increased the said increase must be figured in the cost of the system and the cities would necessarily be required to pay for the service on the basis of the higher valuation.

The capital investments required in the proposed systems are set out in the two tables which follow

Capital Investments, Fixed Charges, Etc

Southern System

Regina plant purchase	$1,100,000 00	
New unit 1929	400,000 00	$1,500,000 00
New unit 1934	600,000 00	2 100,000 00
Fixed Charges—		
Administration	10,000 00	
Interest and sinking fund—		
$1,500,000 at 7½%	112,500 00	$ 122 500 00
$ 600,000 at 7½%	45,000 00	167 500 00
Moose Jaw		
Plant purchase	800,000 00	
New Boilers	165,000 00	$ 965,000 00
Transmission line 42 miles at $3,000.00		126,000 00
Transformers 2- 9,000 K W		300,000 00
		$1,391,000 00
Fixed Charges—		
Administration	4,800 00	
Interest, sinking fund, etc		
$1,391,000.00 at 7½%	104,325 00	
Maintenance Trans line 42 miles at $113.50	4,767 00	$ 113,892 00

Capital Investments, Fixed Charges Etc

Northern System

Saskatoon—		
Plant purchase	$ 800,000 00	
New plant 1929	1,500,000 00	$2,300,000 00
New plant 1934	600,000 00	2,900,000 00
Fixed Charges—		
Interest and sinking fund $2,300,000.00 @ 7½%	$ 172,500 00	
Administration	7 500 00	$ 180,000 00
1934 new unit $600,000.00 @ 7½%	45,000 00	225,000 00

Prince Albert—

Plant purchase	$ 200,000 00	
Transformers	115,000 00	
Transmission Lines	225,000 00	$ 540,000 00

Fixed Charges —

Interest and sinking fund, etc, $540,000 00 @ 7½%	$ 40,500 00	
90 miles T Line x $113.50	10,215 00	
Administration	1,800 00	$ 52,515 00

North Battleford—

Plant purchase	$ 100,000 00	
Transformers	115,000 00	
T Lines 98 x $2,500	245,000 00	$ 460,000 00

Fixed Charges—

Interest and sinking fund, etc, $460,000.00 @ 7½%	$ 34,500 00	
98 miles T Line x $113.50	11,123 00	
Administration	2,077 00	$ 47,700 00

A statement of costs of production has been worked out based on the assumptions of power output and capital invested already tabulated and is shown in the tables which immediately follow

It has been further assumed that the cost of generating at these plants covering fuel attendance, maintenance and supplies is .65 cents per K W H for the first three years, and .6 cents per K W H for the following years The tabulations are on a basis of costs, and do not provide for a contingency fund

Costs

Regina $1,500,000 @ 7½% = $112,500.00				$2,100,000 @ 7½% = $157,500.00		
Year	1930	1931	1932	1933	1934	1935
Generating Costs	Millions K W H 38.9 x .65 cts	Millions K W H 42.8 x .65 cts	Millions K W H 47 x .65 cts	Millions K W H 51.8 x .6 cts	Millions K W H 57 x .6 cts	Millions K W H 62.6 x .6 cts
Generating	$252,850	$278,200	$305,500	$310,800	$342,000	$375,600
Fixed charges	122,500	$122,500	$122,500	$122,500	$167,500	$167,500
Total	$375,350	$400,700	$428,000	$433,300	$509,500	$543,100
Cost per K W H	0.965 cts	0.936 cts	0.911 cts	0.836 cts	0.894 cts	0.8675 cts
						Average 0.8963

Moose Jaw						
Generating costs	Millions K W H 18.7 x .65 cts	Millions K W H 20.6 x .65 cts	Millions K W H 22.6 x .65 cts	Millions K W H 24.9 x .6 cts	Millions K W H 27.4 x .6 cts	Millions K W H 30.1 x .6 cts
Generating	$121,550	$133,900	$146,900	$149,400	$164,400	$180,600
Fixed charges	113,892	$113,892	$113,892	$113,892	$113,892	$113,892
Total	$235,442	$247,792	$260,792	$263,292	$278,292	$294,492
Cost per K W H	1.26 cts	1.202 cts	1.154 cts	1.057 cts	1.015 cts	0.9781 cts Average 1.095

Costs—Northern System

Average = 1 1442 cts

Year	1930	1931	1932	1933	1934	1935
Saskatoon						
Generating costs	Millions K W H 29 x .65 cts	Millions K W H 31 9 x .65 cts	Millions K W H 35.1 x .65 cts	Millions K W H 38.6 x .6 cts	Millions K W H 42.5 x .6 cts	Millions K W H 46 7 x .6 cts
Generating	$188,500	$207,350	$228,150	$231,600	$255,000	$280,200
Fixed charges	$180,000	180,000	180,000	180,000	225,000	225,000
Total	$368,500	$387,350	$408,150	$411,600	$480,000	$505,200
Cost per K W H cts	1 27	1 214	1 163	1 066	1 13	1 082
Prince Albert						
Generating costs	Millions K W H 4 9 x .65 cts	Millions K W H 5.4 x .65 cts	Millions K W H 5 9 x .65 cts	Millions K W H 6.5 x .6 cts.	Millions K W H 7.2 x .6 cts	Millions K W H 7 9 x .6 cts
Generating	$ 31,850	$ 35,100	$ 38,350	$ 39,000	$ 43,200	$ 47,400
Fixed charges	$ 52,515	52,515	52,515	52,515	52,515	52,515
Total	$ 84,365	$ 87,615	$ 90,865	$ 91,515	$ 95,715	$ 99,915
Cost per K W H cts	1 722	1 623	1 54	1 41	1 33	1 265
Cost and 10% for Tran Loss	1 894	1 785	1 694	1 55	1 463	1 391

North Battleford

Generating costs	Millions K W H 2.11 x .65 cts	Millions K W H 2.32 x .65 cts	Millions K W H 2.55 x .65 cts	Millions K W H 2.81 x .6 cts	Millions K W H 3.09 x .6 cts	Millions K W H 3.4 x .6 cts
Generating	$ 13,715	$ 15,080	$ 16,575	$ 16,860	$ 18,540	$ 20,400
Fixed charges	$ 47,700	47,700	47 700	47,700	47,700	47,700
Total	$ 61,415	$ 62,780	$ 64,275	$ 64,560	$ 66,240	$ 68,100
Cost per K W H cts	2.91	2.706	2.55	2.298	2.143	2.003
Cost and 10% Tran Loss	3.2	2.977	2.805	2.528	2.357	2.203

We have worked out a number of trials using different scales of rates per K W H at which the energy might be sold to the large centers We assume that for the purpose of negotiation some such schedule will in any event be necessary as the municipal authorities will want some definite assurance as to the costs which the plan may involve The trial schedule of rates which we are submitting herewith is one which has given weight to the study of costs in the table set out above, and has further been planned so as to give due weight to the element of progression in the consumption We feel that this schedule provides a reasonable degree of equity and a reasonably safe basis for economical operation of the system The first table, which immediately follows, sets out a scale of rates at the different centers with no reference to the years described in the former tables, but with reference solely to the amounts of energy taken by each municipality

SOUTHERN SYSTEM

Regina		*Moose Jaw*	
Millions K W H used per year	Rate cents per K W H	Millions K W H used per year	Rate cents per K W H
30	0.98	15	1.25
35	0.96	20	1.20
40	0.94	25	1.15
45	0.92	30	1.10
50	0.9	35	1.05
55	0.89	40	1.0
60	0.88		
65	0.87		
70	0.86		
75	0.85		
80	0.84		
85	0.83		

NORTHERN SYSTEM

Saskatoon		*Prince Albert*		*North Battleford*	
Millions K W H used per year	Rate cents per K.W H	Millions K W H used per year	Rate cents per K.W H	Millions K W H used per year	Rate cents per K.W H.
25	1.30	4	2.3	1.5	3.5
30	1.25	4.5	2.2	2	3.3
35	1.20	5	2.1	2.5	3.1
40	1.15	5.5	2	3	2.9
45	1.10	6	1.9	3.5	2.7
50	1.05	6.5	1.8	4	2.5
55	1.0	7	1.7		
		7.5	1.6		
		8	1.5		

An application of the above scale of rates over the combined system to the consumption already projected is set out in the table which immediately follows This table indicates the revenue which would be derived on this basis and also indicates the expenses, and when the two items are balanced, shows a net profit in each of the six years which should be accumulated at the end of the sixth year to a sum of $529 638 This amount of surplus on operation is a small margin, and represents only 073 cents per K W H on the total output. A revision of the scale of rates which would yield a cumulative surplus in the six years at the round figure of five one-hundredths of a cent per K W H would yield $36, 140 surplus

COMBINED SYSTEM

Total Revenue

Year	1930	1931	1932	1933	1934	1935
	$	$	$	$	$	$
Regina	38 9x .96 = 373,440	42.8x 94 = 402,320	47 x 92 = 432,400	51 8x 9 = 466,200	57 x 89 = 507,300	62.6x .88 = 550,880
Moose Jaw	18 7x1 25 = 235,750	20.6x 1 2 = 247 200	22.6x1.2 = 271,200	24 9x1 2 = 298,800	27.4x1 15 = 315,100	31 1x1 1 = 331,100
Saskatoon	29 x1 3 = 377,000	31 9x1 25 = 398,750	35 1x1 2 = 421,200	38 6x1 2 = 463,200	42.5x1 15 = 488,750	46 7x1 1 = 513,700
Prince Albert	4 9x2 2 = 107,800	5.4x2 1 = 113,400	5 9x2.0 = 118,000	6.5x1 8 = 117,000	7 2x1 7 = 122,400	7 9x1 6 = 126,400
North Battleford	2 11x3.3 = 69,630	2.32x3.3 = 76,560	2.55x3 1 = 79,050	2.81x3 1 = 87,110	3.09x2 9 = 89,610	3 4x2 9 = 98,600
Total Revenue	$1 161,620	$1,238,230	$1,321,850	$1,432,310	$1,523 160	$1 620,680

Total Costs

	$	$	$	$	$	$
Generating Expense	93.61x.65 = 608,465	103 02x 65 = 669,630	113.15x.65 = 735,475	124.6x.6 = 747,660	137 9x.6 = 823,140	150 7x 6 = 904,200
Fixed charges	516,607	516,607	516,607	516,607	606,607	606,607
Total Expense	1 125,072	1,186,237	1,252,082	1,264,267	1,429,747	1 510,807
Net Revenue	36 548	51 993	69,768	168,043	93,413	109,873
Cumulative Revenue	36,548	88,541	158,309	326,352	419,765	529,638

From the statements above it will be noted that we have allowed as capital investment covering the purchase and extension of the principal plants of $6,700,000, of which $5,500,000 will be needed at the outset and $1,200,000 in 1934. In our capital costs we have included 7½ per cent to cover interest and sinking fund. A further allowance of 1 per cent for contingencies, would represent in the 6 years $354,000 which is almost equivalent to the accumulative surplus on the basis of cost plus five one-hundredths of a cent per K.W.H. Some allowance has been made in our former estimate for the central administration cost. The foregoing is briefly tabulated, as follows

Capital Investment—
$5,500,000 at once
$1,200,000 in 1934

Allowances for Contingencies—

$5,500,000 @ 1% x 6 years =	$330,000
$1,200,000 @ 1% x 2 years =	24,000
	$354,000

Consumption 722,280,000 K.W.H. during years 1930 to 1935.
Cumulative surplus $329,638 = 0.073 cents per K.W.H. on above consumption.
Revised cumulative surplus $361,140 = 0.05 cents per K.W.H.
Compare with $354,000 above allowance for contingencies.

The station generating costs are taken at 0.65 and 0.6 cents per K.W.H. and on this basis cost plus 0.05 cent per K.W.H. will give 1 per cent on capital for contingency and leave no profit but provides for some administration cost.

In this discussion of Question No. 2 we have been obliged to include a discussion of costs, which are referred to in Question No. 4, and we do not propose, therefore, to make further comment on this latter question.

Question 3. "As to whether it is desirable that such central "plants should be operated in conjunction with the production of "char, briquettes and other by-products."

Elsewhere in this report, we have pointed out that under present conditions and for some time to come, establishment of a large central power plant on the Lignite Coal Fields of Southern Saskatchewan as a means of supplying energy to a large part of the province is not the most economical solution of the problem, on account of the high efficiencies of existing plants in the large cities, their investments which must continue to be carried and on account of the costs of the transmission line. As the province develops and greater demands for electric energy present themselves, it may be assumed that there will be room in any general scheme for a large plant at the coal fields, and in the design of such plant, provision should be made that the processing of coal could be undertaken that is, room should be left so that coal dryers using stack gases as a drying means could be placed in the boiler room when desired. Room should also be provided on the site for a coal treating plant when such is found to be commercially worth while. While many experimental plants for the treatment of coal have been built both in America and Europe, none to our knowledge

has been of sufficient commercial success to be recommended for installation in a central plant

Some examples of these plants may be cited for the carbonisation of power plant fuel

1. The McEwen Runge process of the International Combustion Engineering Corporation installed in connection with the Lakeside Plant of The Milwaukee Electric Railway and Light Co a 145,500 K W Power Station built in 1920 at cost of over $16 000,000 This Coal Treating Plant is still in the experimental stage and has not yet been put on the market
2. The Piron Caracristi process at the Ford Motor Co works at Walkerville, Ont Although Mr Caracristi has recently published an excellent account of the difficulties encountered in the development of this plant, the Ford Motor Co. have discontinued further development work.

For the production of an improved smokeless domestic fuel might be mentioned

1. The McIntire Process of the Consolidated Coal Products Co , Fairmont, W Va
2. The Greene-Laucks process of the Old Ben Coal Corporation, Illinois
3. The Parr Process developed at the University of Illinois at Urbana, Ill , by Dr Parr

None of these, however, can be considered as adjuncts to a power plant with the view of using the heat of the stack gases

The Provincial Government has for some years been carrying on investigations and experiments into the question of the utilisation of the lignite in their coal fields in the south of the province, and the progress has been referred to in a number of public reports

These reports discuss the utilisation of lignite principally as follows

The carbonisation of lignite with gas as a by-product, which gas might be available for use in gas engines for power purposes

As processes for the carbonisation of lignite have nowhere been proved in this or adjoining provinces and no considerable market for this product in this or adjoining provinces has yet been developed, the availability of gas for the use of gas engines for power development on the large scale under consideration in this report is not assured Assuming however that sufficient quantities of gas were available we would point out that the cost of installation of a gas engine plant and electric generators would be higher than the cost of the steam plant. Power plant practice on the Continent of America, where billions of dollars are invested, points to the general adoption of steam boilers and high speed steam turbines with comparatively low cost generators in large plants as the most efficient installation. This is also the tendency in other parts of

the world As a result, engineering works are organised largely to supply equipment for this process and the resultant competition and large production make possible low costs for the installation

When it is remembered that the fuel cost in a system comprising a central power plant and large capacity transmission line is a relatively small item note that in the Consulting Engineers' report attached, a system of this kind shows the total cost per K W H 1 17 cents of which the fuel cost is 0.3 cents) the consideration of a gas engine plant would only be possible where a definite saving in fuel costs can be effected With the higher fixed charges and maintenance charges on a gas engine plant, this would be impracticable in the present instance

We have discussed the relative cost of freighting fuel or transmitting energy between the coal fields and Regina on the basis of raw fuel If carbonised coal were considered a somewhat similar conclusion would result so that the carbonised coal would be preferably used at the Regina plant.

We are not satisfied that from the point of view of the generation of cheap power from coal, it has been so far established that by the processing of the coal a substantial advantage can be secured over the use of the coal in its raw state

Question 4 "The probable cost of power produced by such plant or plants, the distance to which such power could be economically transmitted and the price that would have to be charged for such power at the various points in the province to which it might be transmitted"

This question has already been dealt with in the reply to Question 2

Question 5 "The capacity of existing power plants in the province and their present output present selling price of current and present cost of production"

Appendix No 2, which is attached, sets out in detail most of the information requested in this question The figures given in the schedules respecting the sale price of current represent the average price to the consumer for light and power and the figures respecting the cost of production are also average figures arrived at by dividing the total output into the total cost The rates schedules are divided into classifications along general lines as follows

1 Domestic light and cooking
2 Commercial light
3 Commercial power
4 Industrial light and power
5 Power for municipal purposes
6 Street lighting

and these various services are supplied at different rates which are adjusted as far as possible to be equitable between the different classifications

We do not consider it necessary for the purposes of this report to go into the question of rate structures at any length. In general we would point out that the sale price of energy ranges from 35 cents per K.W.H. down to 1 cent, the larger figure being the charge in some of the small towns for domestic light and the low rate for 24 hour power loads in the cities.

The cost of production ranges from 20 cents down to 1.08 cents. The 1 cent rate is not an out-of-pocket rate as it would appear as it more than covers the cost of fuel to produce the energy and does not add to the labour and overhead costs.

We have had prepared a comparison of typical net bills issued in Regina for various services as compared with net bills issued in other cities for the same service and consumptions. This comparison indicates what efficient plants in Saskatchewan are capable of providing to the consumer with some relation to the practice elsewhere, where water power is available.

In any power service the costs are divided between capital costs and operating costs and the capital costs represent relatively a large proportion of the total. The power plant must be guaranteed a return sufficient to cover these costs and it is usual to adjust the schedules of rates so that the first blocks of energy supplied are at a higher rate and that the later blocks can be supplied after the capital costs are largely secured, at a minimum sufficient to cover operating costs. With steam plants these later blocks require the supply of fuel to be figured in the costs but in connection with water power there is practically no further cost and on this account with water power installations the later blocks of energy sold are supplied at a much lower rate. Where water powers are referred to it must be assumed that the cost of development of the water power has been possible within reasonable limits, as in many instances water power, on account of the high cost of development, is found unable to compare favorably with steam power where fuel can be obtained at low cost.

Comparison of Typical Net Bills Issued in Regina for Industrial and Domestic Current Compared with Net Bills Issued in Other Cities for Same Service and Consumptions

Nature of Business conducted	Demand for month	K W H cons per month	Regina bill	Calgary bill	Edmonton bill	Winnipeg Hydro bill	Walkerville Hydro bill
Packing Plant	90 K W	24 ,60	$ 438 01	$ 200 09	$ 307 42	$ 345 87	$ 27. 82
Oil Refinery	340 K W	203,400	2,562 80	1 945 65	2 458 30	1,192 31	1,360 08
Creamery	132 K W	40,080	601 92	441 35	473 54	553 54	412 47
Railway Shop	65 K W	27,040	378 74	3.3 10	324 39	316 21	224 81
Publishing Co	82 K W	28,336	523 88	332 60	339 66	350 43	266 44
Hospital	96 K W	30,200	559 53	357 27	360 90	378 36	303 11
Department Store	80 3 K W	18,433	367 15	225 10	226 75	3 .5 72	333 75
Dress Goods Store	9.6 K W	1,350	49 95	38 80	89 30	39 60	30.31
Furs and Ladies Ready-to-wear	4 60 K W	850	32 90	28 80	59 38	24 90	16 95
Average Domestic Light	. K W	57	2 69	2 85	4 34	1 71	1 58
Average Domestic Combination of Light and Heat	. K W Light 7 K W Heat	271	7 30	6 23	10 10	3 50	4.03

Comparison made June 22nd, 1928

The above tabulations refer to the sale prices of current in the larger cities, where low rates are available because of the large demand These conditions do not exist in the smaller communities and the reason is not because of any inefficiency in the installation or its operation but rather on account of the small loads which are available and the fact that the minimum of superintendence and labour required to supply the service represents many times the cost per K W H that the same labour and supervision represents with such loads as the larger cities supply A further table is set out below which indicates the cost to the consumer of the services in our smaller centers

TABLE

Comparison of Typical Net Monthly Bills in Saskatchewan Cities, Towns and Villages for Various Classes of Consumers in 1926

Class of consumer	Residential lighting	Combined domestic light and cooking	Commercial lighting	Small power consumer	Large power consumer
Maximum demand	1 K.W	8 K.W	3 K.W	5 K.W	50 K.W
Monthly consumption K W H	20	300	150	500	3,000
Monthly Bill					
Cities—					
Moose Jaw	$1 94	$13 37	$11 48	$21 38	$168 75
North Battleford	2 10	15 20	14 60	30 25	135 25
Prince Albert	2 25			22 50	
Regina	1 35	7 62	6 93	20 43	108 18
Saskatoon	1 60	12 40	12 87	23 00	113 00
Swift Current.	2 80	17 00	20 00	30 00	200 00
Weyburn	2 48			34 88	
Yorkton	2 88	20 50	24 00	31 50	161 50
Towns and Villages—					
Aberdeen	6 00		45 00	150 00	
Arcola	5 25		23 44	75 94	
Avonlea.	6 00		45 00	150 00	
Assiniboia	3 50		23 00	43 50	241 00
Battleford	2 72		20 00	44 00	
Balcarres.	6 80		37 75		
Balgonie.	6 90		48 50		
Bengough	6 00		45 00	150 00	
Briercrest	7 30		48 00		
Broadview	5 40		44 55	30 00	
Cabri	7 50		40 00		
Carlyle	4 95		37 62		
Ceylon	6 28		43 23	142 98	
Coderre	5 70		42 75		
Craik	5 25		38 00		
Cupar	6 75		52 85		
Dairdoon	3 45		24 25	80 00	
Duck Lake	7 27		44 82		
Elrose	6 50		39 50		
Estevan	2 52				
Eyebrow	6 00		45 00	150 00	
Fillmore	6 00		45 00		
Glenavon	7 00		52 50		

Govan	$5 10	$	$37 50	$	$
Grenfell	3 69		29 80		
Hawarden	6 44		43 88		
Herbert	4 25		30 25		
Hodgeville	6 00		45 00		
Humboldt	4 25		15 50		
Indian Head	3 45		27 25		
Ituna	6 50		45 30		
Kamsack	3 25				
Kelliher	6 10		42 50		
Kinistino	5 85				
Lake Lenore	4 50		30 50		
Lang	4 55		31 85		
Langenburg	7 00		52 50		
Langham	4 25		30 25		
Lashburn	5 45		39 38		
Lemberg	6 00		35 50		
Leslie	5 00		33 75		
Lloydminster	4 50		23 80		
Loverna	5 25		37 75		
Lumsden	4 25		30 25		
Lockland	6 50		45 50		
Maple Creek	3 25		22 75	50 00	
Marquis	6 00		45 00		
Maymont	6 00		45 00		
Melfort	3 60		29 70		
Melville	3 60		27 00	44 25	219 25
Milden	5 00		37 50		
Morse	5 35		37 85		
Mortlach	5 85		40 95		
Nokomis	6 35		45 35	75 00	
North Regina	2 70		15 20		
Outlook	3 42		26 73		
Oxbow	4 14		31 05		
Pelly	5 00		37 50		
Perdue	5 00		37 50		
Qu'Appelle	5 25		37 75	60 00	
Radisson	5 35		37 85		
Radville	4 19				
Raymore	6 10		42 50		
Readlyn	9 00		67 50		
Reevers	7 00		52 50		
Rosetown	3 85		24 25	60 25	
Rosthern	3 60		27 00		
Saltcoats	4 00		30 00		
Scott	4 25		30 25		
Semans	5 70		36 00	120 00	
Shaunavon	3 25				
St. Boswell's	6 00		45 00		
Star City	5 74				
Summerberry	8 25				
Sutherland	3 40		25 50		
Tisdale	3 78		28 35		
Tompkins	5 60		38 10		
Tugaske	6 40		48 00		
Tuxford	6 40		48 00		
Unity	3 73		27 23	58 73	
Vanguard	6 00		90 00		
Vibank	5 35		37 85		
Viscount	7 00		52 50	75 00	
Vonda	5 25		37 75		
Wadena	4 25		30 25		
Wapella	6 50		45 50		
Watson	6 00		45 00		
Wawota	6 00		45 00		
Wilcox	5 35		37 85		
Wilkie	3 73		25 88	54 23	
Wolseley	3 83		24 20	80 00	
Wynyard	5 65		40 73		
Yellowgrass	5 25				
Young	5 00		37 50		

Question No 6 —As to whether or not

(a) The development of transmission of power in Canada or elsewhere has tended to the electrification of the farms which are adjacent to the transmission lines and which can be served thereby,

(b) The use of electricity on the farms has materially increased since the distribution of power in other provinces or elsewhere,

(c) The transmission of power in this province would create a material demand from the farming communities for electrical energy

As to whether it would be desirable to utilise existing pole lines in the province for the transmission of power in rural districts and sparsely settled localities

A great deal of information has been collected by Mr Blackburn relative to rural electrification Wherever electric energy is available from transmission lines the residents of the rural community have been ready to make use of it Generally speaking the small loads distributed to the rural districts would not of themselves justify the construction of transmission lines but where transmission net works have been constructed to serve cities towns and villages they may be readily adapted to the services of the rural communities through which they pass.

It may also be asserted that the initial usage which the rural resident makes of the energy will be later increased as he becomes more familiar with its use and as further appliances are provided him Much has been done in this regard by the Educational Campaigns adopted by officials of the power companies throughout the rural districts We believe, therefore that transmission of energy in this province would create a material demand from the farming communities for electric energy

We question the desirability of using existing telephone pole lines in the province for the transmission of power to the rural districts These lines were constructed with no intention of such use and in most instances are not suitable. It may be that any general scheme for the extension of power transmission lines to the rural districts could later be combined with new telephone installations which may be required as the present installations become inadequate or require renewal For the full discussion of the problem of rural electrification we would refer to the report Appendix No 9, which is attached hereto

Question No 7 "Whether or not it would be advisable for "municipalities owning and operating power plants to be granted "the privilege of selling energy outside the corporate limits of the "municipalities and for such purpose to be granted power under "provincial regulations to construct own and maintain power "transmission lines outside the limits of the corporation and "interconnected with existing plants "

The cost of power produced in the large city stations has been reduced to minimum proportions as has been hereinbefore pointed out. There is an enormous range between these costs and the costs procurable by the small centres in their own power plants. Within certain limited distances cheap transmission lines can be constructed to reach out from the city stations to serve a considerable number of the smaller communities at a very much reduced cost and there is no question that advantage of the situation as described should be taken.

We have in this report pointed out that the tendency in the development of the individual stations is to plan primarily for the needs of each community without reference to any wider scheme throughout the province and have suggested that as time goes on there will be a duplication of equipment which will be costly, unless there is a general plan of organisation, either of the efforts of the large city installations under a pooling arrangement or by the consolidation of these plants into one general scheme. If such a plan can be worked out the question is answered. Failing such a plan these larger plants should be empowered to extend outside their corporate limits, but such extensions should be regulated to ensure that the sphere of influence of each large plant will not overlap other spheres, and that a proper standard of construction is maintained.

Question No. 8.—"As to what, if any, hydro-electric possibilities "there are in the province."

The total water power available in the Province of Saskatchewan is estimated by the Department of the Interior at 542,034 H.P. at ordinary minimum flow based on the average of the minimum flow for the two lowest periods of seven consecutive days in each year for seven years or less according to the length of period for which records are available. The available H.P. based upon the continuous power indicated by the flow of the streams for six months in the year is estimated at 1,032,531 H.P. These water powers are all situated in the northern part of the province, there being no water powers of importance in the southern part. The northern part of the province is sparsely settled and while the water powers are of great potential importance for developing the mineral and timber resources which probably will eventually absorb all the water power available the water powers are too distant from the more settled parts of the province for immediate economic development and it is probable that the greater portion of the power requirements of the central and southern part of the province will continue to be derived from fuel, at least for some time to come.

The northern portion of the province has two main drainage systems of which the Churchill River, draining directly into Hudson Bay is the larger. The other system which drains a considerable area in the north west corner of the province drains directly into Lake Athabasca and thence to the Slave and Mackenzie Rivers and to the Arctic Ocean. South of the Churchill River are the North and South Saskatchewan Rivers which uniting

about 30 miles East of Prince Albert, flow into Lake Winnipeg. There is a very considerable variation between the maximum and minimum runoff of the Saskatchewan River, which rises in the glaciers of the Rocky Mountains and receives comparatively little runoff from the prairies. In early summer when the snow melts a large volume of water flows but the flow in winter is comparatively small. In the spring when the snow is melting, the Saskatchewan River receives a considerable volume of water from the prairie tributaries, but in winter when the precipitation is held in the form of snow there is very little runoff from the prairies. The variation in flow is not so great on the Churchill and Northern rivers as the large lakes, swamps and muskegs exercise considerable regulating effect.

A list of the water powers in the province with particulars of flow and power available, compiled from information supplied by the Department of the Interior, is given in Appendix No. 10, also a map showing locations of water power sites.

None of the water powers in the Province of Saskatchewan have been developed. Some development work, however, has been done at LaColle Falls on the North Saskatchewan River about 26 miles below Prince Albert, where in 1912 the city of Prince Albert contracted for the construction of a power plant. It was proposed to provide for a canal lock on the right bank of the river with an Ambursen type of dam extending across the river, and a power canal, power house and tail race on the left bank. The dam would create an effective head of 28 feet, which at the ordinary minimum flow of 1,351 cubic feet seconds would develop 3,430 H.P., assuming an overall efficiency of 80 per cent. The estimated flow of the river for maximum development (without storage) is 5,846 cubic feet per second, which would correspond to a possible development of 14,880 H.P. This is figured on the ordinary 6 months flow and assumes the provision of a steam stand-by plant to be used during low river periods. Development operations proceeded continuously until July, 1913, when work was stopped due to lack of funds. During this period a canal lock was nearly completed, and a dam was built about two-fifths the distance across the river. The excavation of the tailrace and power canal was about 90 per cent completed.

The power situation at LaColle Falls and at the Forks together with the estimated cost of completing the development of these water powers has been thoroughly investigated by the Consulting Engineers and full particulars are given in their report.

The investigation indicates that there is no immediate prospect of the economic development of the water powers of the Saskatchewan River, and as has already been pointed out, the water powers in the more northerly part of the province are too far away from the centres of population for their immediate economic development.

Rapid progress is being made, however, in the transmission of power to long distances and it is quite possible that the increasing density of population and the development of higher transmission

voltages may at some not far distant date render it economically possible to develop some of these water powers to meet the needs of the more thickly settled parts of the province. In this connection the progressive increase in transmission voltages and the consequent increase in the distance over which power can be transmitted economically may be briefly indicated.

The first electrical long distance transmission line was operated in 1889 at Willamette Falls, Oregon, at a transmission voltage of 4 000 volts; in 1892 electric current was transmitted at 10 000 volts over a 28 mile line at San Antonio, California. In the following year a transmission line was installed at Redlands, California, over which energy was transmitted at 11 000 volts. The same voltage was used between Niagara Falls and Buffalo in 1895. Electric energy was transmitted at 25 000 volts by The Pioneer Electric Power Co. in Utah in 1896, and during the following years transmission voltage was gradually increased to 60 000 volts. In 1908 a 110 000 voltage transmission line was installed at Grand Rapids, Michigan, and a similar voltage was also used by the Great Western Power Co. in California. A 150 000 volt transmission line was built in 1913 by the Pacific Light and Power Co., and 1923 a 220 000 voltage line was installed by the Southern California Edison Co., and a similar line by the Pacific Gas & Electric Co. A number of long distance lines transmitting power at this voltage have since been installed or are in the course of construction.

Further developments are in sight, and it is claimed that the recently proposed application of synchronous condensers at intermediate points in the transmission line will increase the economic radius of electrical transmission of power very considerably.

Question No. 9. "As to whether it would be possible under "existing conditions to develop any of these water-powers to "economic advantage."

The Consulting Engineers' report, pages 172 to 190 inclusive, together with a considerable number of graphs and charts attached, goes very fully into the discussion of this question. The water powers in the far north of the province are too distant from centers of population to be of any immediate interest, except to such industries as may locate in the far north. The cost of transporting material for the river works and the cost of erecting a transmission line through unsettled territory, and with the lack of transportation facilities, would bring the initial cost of the system so high that it could not hope to compete with a modern steam plant. The Consulting Engineers have confined their serious consideration to the power which might be developed on the Saskatchewan River at a point below the Forks about 38 miles from Prince Albert, and at LaColle Falls, the latter location being the site of development already started by the city of Prince Albert but abandoned some years ago. There are no falls on the river, and the head for power purposes must be provided by the erection of dams across the river. The banks of the river are only of moderate height, so that the heads which dams would make available are also moderate. The flow in

the river is extremely variable between the winter period of low water and the summer period of high water, and unfortunately for practical purposes the power loads are heaviest in the winter. The low water flow of the river in the winter is equivalent to 12,000 K.W. with a working head of 50 feet, which is about the maximum permissible between the benches of the river; this is less than the combined demand of the three cities in 1926, which was 18,000 K.W. It is evident that the city plants would require to be developed concurrently with the water-power plant for winter conditions, and that the carrying charges on both investments must be provided in addition to all operating costs. The estimated costs of development at the Forks are set out on page 188 of the Consulting Engineers' report, and shows the cost of 50,000 K.W. and 20,000 K.W. development.

With the smaller capacity the fixed charges would be $506,000 per annum. The fixed charges on a transmission line with transformers to Saskatoon amounting to $222,000 per annum (see pages 189 and 190) added to this would give a fixed charge on a system to Saskatoon alone of $728,000, or if the pole line were extended to Moose Jaw and Regina with transformers added, an additional $300,000 fixed charges per annum, making a total of $1,028,000. When it is remembered that the 1935 consumption at the Saskatoon center is estimated at 60,000,000 K.W. hours, and that the combined consumption of the cities of Saskatoon, Moose Jaw and Regina would total a little less than one hundred and fifty million K.W.H., it is evident that in the first case the fixed charges alone would represent 1.2 cents per K.W.H., and in the second case .7 cents per K.W.H. The figures represent a higher cost than the cost of fuel and supplies at the city plants.

For a full discussion of these elements of cost the Engineers' report should be referred to.

They have, however, discussed the practicability of development at the Forks at a time in the future when the summer load of the province reaches such proportions as to take the fullest advantage of the power which might be developed at the Forks. The output at the Forks station under such conditions would be many times what would be demanded for many years to come, and it is only by spreading this much larger output over the fixed charges on such an installation that the unit costs of production could be so lowered as to be of interest considered in conjunction with the city plants. The Engineers' report further shows that the reasoning with regard to the Forks location would be even more pronounced if applied to the La Colle Falls location, and this after taking advantage of the expenditures already made by the city of Prince Albert.

Question No. 10. "As to what type of construction of transmission and distribution lines would be most suitable to conditions "prevailing in this province."

Throughout the report of the Consulting Engineers much data is submitted as to the types of transmission lines which might be utilised, and as to their costs. In considering the central plant with

a large capacity transmission line to feed the three cities, an expensive type of steel tower construction was recommended (see page 159). A wood pole line to give the same service would cost less for initial investment, but when its life time is taken into consideration and the increased number of poles and insulators required is figured, a wood pole line would be equivalent in annual cost and not as reliable an installation. For a service such as a line between Saskatoon and Prince Albert or between Saskatoon and Battleford, the Engineers consideration on pages 162 to 164 is referred to. The type discussed is 66,000 volt 3 phase transmission line on wood poles with the capacity of the service 5,000 K.W. The poles are butt treated. The estimated cost is $2,826 per mile. This type of construction we consider should be adopted for such service.

For such a service as radiating lines from the central plants where a number of smaller towns are to be connected, and where the total capacity is relatively small, a cheaper pole line for 13,200 volts, 3 phase transmission on wood poles might be adopted and would cost approximately $1,400 per mile.

A pole line from the radiating lines to serve a number of rural consumers would not need to be as expensive as the types just discussed. Particulars of this type of line are given in the report of Mr. Blackburn, Appendix No. 9, the cost per mile ranging from $600 to $700.

We believe that the steel tower installation would be warranted when conditions of load reach such proportions as may be expected beyond 1935, but that the wisest plan at the outset is to adopt a type which represents the lowest capital cost. This report indicates throughout that the bulk of the load in the province is in the three cities, and the discussion proposes to supply energy at cheaper cost to a large territory which may be reached from the three large cities. We believe that the estimates submitted as to the use of the service by these smaller communities are conservative. There are great possibilities when such a service is available for increased use of same, and the actual experience in the course of 10 or 15 years from the institution of the service may be such as to warrant at the end of that time considerable modification in the general plan of distribution; for this reason we believe it would be wise at the initial stage to adopt a relatively cheap type of transmission line.

Question No. 11. "As to whether there is at present a sufficient market for the power which would be produced at any such "central power plant or plants."

and

Question No. 12. "As to whether if there is not such a market "at present, the production of power at such plant or plants and the "sale thereof at a low rate would, in the opinion of the Commission, "create a demand for such power."

In the schedules as to existing light and power plants, and in the report of the Consulting Engineers' where the consumption of power until the year 1935 is projected, much information is available as to the market for power. It is indicated in the summary

that the revenue for the power plants in the province for the year 1926 was $2,801,516. The estimated increase in consumption assumed in this report indicates that by 1935 the demand will have reached approximately two and one-half times the present demand. These calculations are based largely on the development to be expected in the larger cities and the rate of growth is not more than has been experienced in these larger centers for many years past. It is very evident from this that power demands of these large cities at present and particularly in a few years to come assume such large proportions as to warrant serious consideration and any means which can be devised to effect a small reduction in present costs will represent in total very large sums of money. The plan we have discussed we believe shows the most efficient method of supplying the demands of these large centers, so that the costs of power may be reduced to a minimum. Outside of the natural increase in consumption which has been estimated we are not in a position to predict that the rates available will induce further consumption in serious proportions. As already indicated the costs in these large centers are at present quite low and the civic authorities have been in a position to quote low rates to large power users. Experience has not proved that the establishing of industries has been prevented by the costs of power. We believe there are many other factors of cost which have governed this situation. The municipalities will still retain the right to sell power and to the extent that the plan outlined herein improves their present basis of costs they can quote further reduction where conditions warrant special consideration being granted to large users of power.

The largest proportionate increase in the demand for electric energy when the rates are reduced should come from the smaller centers of the province which may be served. A reference to Table No. 3 in the report of the Consulting Engineers indicates that the consumption per head of population in towns under 900 population averages 55 K.W. hours per annum and in towns between 900 and 3,000 population the average is 160 K.W. hours per annum. The present rates in these communities are relatively high and when a system of supply from a network of transmission lines is put into effect the rates may be very materially lowered, and the demands on a conservative estimate will be at least doubled. We are of opinion that while the large centers absorb over 80 per cent. of the total electric energy produced in the province at the present time, that the supply of cheaper energy to these smaller communities and to the farm districts will eventually modify the position until approximately 40 per cent. of the total demand will come from these latter sections of the province. When it is considered that the 1935 estimate predicts a demand of 150,000,000 K.W. hours in the cities alone, 40 per cent. of this amount represents a very large service supplied to the people of the smaller communities at such reduced rates as to represent in the total a very large saving indeed over present costs. This latter consideration of itself, in our opinion, is of sufficient interest to justify the plan which has been herein presented.

In conclusion we wish to point out that in our opinion the conditions which obtain respecting the power plants of the three large cities of the province warrant an extension of these plants rather than the erection of one or more new central stations from which the cities would be served by transmission lines. As has been pointed out with the development of the country in some few years the erection of further large central stations may be economical, but we do not believe that this situation will obtain for a number of years to come. We are further of opinion that the production of power in the more settled portions of the province for many years will be confined to the steam power plant. The greatest possibilities for marked improvement in economies are to be expected in the smaller cities, towns and villages when a system of transmission lines from the base plants is established. We are confident that whatever authority undertakes further development in the power field, the operations will be along such lines as suggested herein. We do not believe that in the smaller communities isolated plants can be established to effect substantially better conditions than now obtain. The whole question appears to us to be a question of organizing the portion of the province which is more closely settled into one system served from a few efficient steam plants. Much publicity has been given during the past year to the activities of private companies in securing franchises for light and power service in a number of our Saskatchewan centers. These companies have made attractive offers by way of purchase price to the municipalities and have promised reductions in their present rates. It must be remembered that these offers may be not only the cost of the power plant but of the business of distribution. We believe that the private companies will require to obtain a reasonable return from the monies invested in the business together with a profit on the operation itself, and in our opinion it is obvious that where the present utilities are purchased for amounts greater than the physical value of the existing plants that the communities served will be required during the lifetime of the new franchises to pay higher rates on the basis of this new capitalization. While the larger centers may not be induced to sell their utilities to private companies it is evident that favorable consideration to such proposals has been given and may continue to be given in the other centers of the province. Indeed the larger centers may eventually entertain such proposals. In our estimates for 1935 we predict an annual output of 150,000,000 K.W. hours. On this quantity one cent per K.W. hour represents a million and a half dollars per annum which would permit of a very large inflation in capitalization. With the interconnection by transmission lines a reduction of one cent under present costs to the smaller centers will be but a fraction of the reduction possible. It may be urged that in the larger centers a reduction of one cent under present costs could not be anticipated. While this is true in connection with the costs of production in the larger centers it must be remembered that the basis of rates adopted in the larger centers provide for rates of from 5 to 8 cents per K.W. hour to the domestic consumer ranging downwards to rates to large power consumers almost at cost. On the basis of these rates these municipalities now

make considerable profits and it is not impossible for a private company to arouse a local interest in a proposal to purchase the utility when a very generous purchase price is offered and some promise of reduction to the average consumer is held out. In short, it appears to us that the greatest opportunity for the establishment of an efficient power service in the province points to the business being organized under one authority where the power plants themselves and the transmission lines are owned and operated by the same authority, thus controlling the cost of the production of the power which will be on the basis of minimum capitalization, and leaving to the individual municipality the right to distribute to its own residents, and the control of its own rates.

Respectfully submitted,

SASKATCHEWAN POWER RESOURCES COMMISSION,

(Signed) L. A. THORNTON, Chairman.
ARTHUR HITCHCOCK, Member.
A. R. GREIG, Member.

July 12th, 1928.

APPENDIX No. 1

Copy of Order in Council dated seventh day of January, 1927

H. W. NEWLANDS,
Lieutenant Governor
L.S.]

CANADA

PROVINCE OF SASKATCHEWAN

GEORGE THE FIFTH, by the Grace of God of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, King, Defender of the Faith, Emperor of India.

TO LOUIS AUGUSTUS THORNTON, ESQUIRE, of the City of Regina (Chairman), ARTHUR HITCHCOCK, ESQUIRE, of the City of Moose Jaw, and ALEXANDER R. GREIG, ESQUIRE, of the City of Saskatoon, OUR COMMISSIONERS in this behalf, and ROBERT NIATT BLACKBURN, ESQUIRE, of the City of Regina, Secretary. GREETING.

J. A. CROSS,
Attorney General.

WHEREAS by The Public Inquiries Act, being Chapter 10 of the Revised Statutes of Saskatchewan, 1920, as amended by Chapter 16 of the Statutes of 1920, it is enacted that the Lieutenant Governor in Council may, when he deems it expedient to cause inquiry to be made into and concerning any matter within the jurisdiction of the Legislature and connected with the good Government of Saskatchewan or the conduct of the public business thereof, appoint one or more commissioners to make such inquiry and to report thereon, and that the Lieutenant Governor may, by the commission by which he appoints them, confer upon the commissioners the power of summoning witnesses before them and to require such witnesses to give evidence on oath, orally or in writing, or on solemn affirmation (if they are persons entitled to affirm in civil matters), and to produce such documents and things as the commissioners may deem requisite to the full investigation of the matters into which they are appointed to inquire, and that the commissioners shall have the same power to enforce the attendance of witnesses and to compel them to give evidence as is vested in any court of record in civil cases.

AND WHEREAS by virtue of the power conferred upon the Chairman of the Board of Highway Commissioners by an Order made in Council on the twenty-fifth day of April, 1912, R. O. Wynne-Roberts, Esquire, was appointed to inquire into the practicability of producing power at coal centres and distributing it throughout the province; that the said inquiry was duly conducted by the said R. O. Wynne-Roberts, and that his report thereon was duly published on the twenty-third day of November, 1912, and placed before the Legislature.

AND WHEREAS since the date of the said last mentioned report the development of the province, coupled with the advancement in the science of producing and distributing electrical energy, and the

discovery and survey of water powers within the province, appear to warrant a further inquiry into the practicability of producing power at suitable centres and at the water power sites in the province and of distributing the same throughout the province

And Whereas Our Executive Council has advised that a Commission do issue under the authority of the Public Inquiries Act, appointing Louis Augustus Thornton, Esquire, of the City of Regina, Arthur Hitchcock, Esquire of the City of Moose Jaw, and Alexander R. Greig, Esquire, of the City of Saskatoon, directing and empowering them to inquire into and report upon the economic practicability of generating power at central power plants and water power sites in the province and the distribution of same throughout the province, and in particular without restricting the generality of the foregoing terms, upon the following matters

1 As to the economic practicability of the construction of central power plants on the lignite coal fields of Southern Saskatchewan

2 As to whether it would be preferable in the alternative or in addition to No 1 to locate central power plants at other suitable points in the province with a view to the ultimate inter-connection of these various central systems.

3 As to whether it is desirable that such central plants should be operated in conjunction with the production of char, briquettes and other by-products

4 The probable cost of power produced by such plant or plants, the distance to which such power could be economically transmitted and the price that would have to be charged for such power at the various points in the province to which it might be transmitted

5 The capacity of existing power plants in the province and their present output, present sale price of current and present cost of production

6 (1) As to whether or not

(a) the development of transmission of power in Canada or elsewhere has tended to the electrification of the farms which are adjacent to the transmission lines and which can be served thereby,

(b) the use of electricity on the farms has materially increased since the distribution of power in other provinces or elsewhere,

(c) the transmission of power in this province would create a material demand from the farming communities for electrical energy

(2) As to whether it would be desirable to utilize existing pole lines in the province for the transmission of power in rural districts and sparsely settled localities.

7 Whether or not it would be advisable for municipalities owning and operating power plants to be granted the privilege of selling energy outside the corporated limits of the municipalities

and for such purpose to be granted power under provincial regulations to construct, own and maintain power transmission lines outside the limits of the corporation and inter-connected with existing plants.

8. As to what, if any, hydro-electrical possibilities there are in the province.

9. As to whether it would be possible under existing conditions to develop any of these water powers to economic advantage.

10. As to what type of construction of transmission and distribution lines would be most suitable to conditions prevailing in this province.

11. As to whether there is at present a sufficient market for the power which would be produced at any such central power plant or plants.

12. As to whether, if there is not such a market at present, the production of power at such plant or plants and the sale thereof at a low rate would, in the opinion of the commission, create a demand for such power.

Now Know Ye that We, having and reposing full trust and confidence in you, Louis Augustus Thornton, Arthur Hitchcock, Alexander R. Greig and Robert Neale Blackburn, do by and with the advice of Our Executive Council and under the authority of The Public Inquiries Act hereby appoint and constitute you Louis Augustus Thornton, Chairman, Arthur Hitchcock and Alexander R. Greig Our Commissioners with Robert Neale Blackburn as Secretary to the Commission to inquire into and report upon the matters hereinbefore specifically set forth.

And We Hereby Confer upon you, Our Commissioners, the power to summon witnesses before you and to require such witnesses to give evidence on oath orally or in writing, or on solemn affirmation if they are persons entitled to affirm in civil matters, and to produce such documents and information as you, Our Commissioners, may deem requisite to the full investigation of the matters into which you are appointed to inquire and that you, Our Commissioners, shall have the same power to enforce the attendance of witnesses and to compel them to give evidence as is vested in any Court of Record in civil cases,

And The Power subject to the approval of the Minister in charge of the administration of the Bureau of Labour and Industries to engage the services of such accountants, engineers, technical advisors or other experts, clerks, reporters, stenographers and assistants as you may deem necessary or advisable and to fix their remuneration,

And The Power within Saskatchewan to issue subpoenas for enforcing the attendance of witnesses and to cause the evidence to be given before you to be taken in shorthand, and to administer or cause to be administered by the secretary of the commission the necessary oaths of witnesses, constables, stenographers and others to whom the oath may be administered to the same extent as may now be administered in a Court of Law,

AND THE POWER to appoint the places in Saskatchewan where and the times when the sittings of you Our Commissioners shall be held and to adjourn the same, if necessary, from day to day and from time to time to enable the matters referred to you to be fully and completely inquired into and investigated

IN TESTIMONY WHEREOF we have caused the Great Seal of Our Province of Saskatchewan to be hereunto affixed

WITNESS Our right trusty and well beloved The Honourable Henry William Newlands, Lieutenant Governor of Our Province of Saskatchewan

AT OUR GOVERNMENT HOUSE in Our City of Regina, in Our said Province, this seventh day of January one thousand nine hundred and twenty-seven and in the seventeenth year of Our Reign

By Command

T C DAVIS,
Provincial Secretary

APPENDIX No 2

Schedule No 1

1926 Statistics of Electric Light and Power Plants in the Province of Saskatchewan

Municipally Owned and Operated Plants

		Population 1926	Type of plant	Engines No. of units	Engines Total capacity H P	D.C or A.C	Generators No of units	Generators Total capacity K W	Distribution lines, miles	Maximum peak load K W
	Cities									
1	Moose Jaw	19,039	Steam	3	9,000	A.C	3	6,000	58	3,925
2	North Battleford	4,787	Steam	2	[illegible]	A.C	2	775	35	610
3	Prince Albert	7,873	Steam	2	3,600	A.C	2	2,000	33	900
4	Regina	37,329	Steam	[illegible]	26,500	A.C	5	16,000	105	8,000
5	Saskatoon	31,234	Steam	[illegible]	13,870	A.C	3	11,000	67	6,100
6	Swift Current	4,175	Prod Gas and Diesel	5	1,740	A.C	4	1,000	21½	520
7	Weyburn	4,119	Steam	2	1,450	A.C	2	750	17¾	405
8	Yorkton	4,458	Diesel	3	1,210	A.C	3	785	17¼	305
			Totals		58,870			38,310	354¾	
	Towns									
9	Assiniboia	1,245	Diesel	2	275	A.C	2	175	4	135
10	Battleford	1,018	Current purchased from North Battleford						7	
11	Broadview	781	Prod. Gas and Diesel	2	100	A.C	2	56	5	29
12	Canora	1,121	Diesel	1	100	A.C	1	50	4½	
13	Carlyle	388	Steam	3	135	A.C	1	35	2	117
14	Davidson	602	Oil Engines	2	140	A.C	2	85	5	45
15	Estevan	2,336	Steam	2	600	A.C	2	420	8	289
16	Govan	456	Oil Engines	2	80	D.C	1	47½	1	
17	Grenfell	699	Prod. Gas	2	80	A.C	2	48	5	31
18	Humboldt	1,75[illegible]	Steam	3	740	A.C	3	400	19	135
19	Indian Head	1,313	Steam	1	235	A.C	1	150	10	93
20	Kamsack	1,948	Diesel	3	600	A.C	3	350	8	175

21	Kindersley	987	Steam	1	125	A.C	1	60	5	57
22	Langham	416	Prod. Gas	1	40	A.C	1	24	4½	14
23	Melfort	1,605	Diesel	2	[illegible]	A.C	2	160	9	183
24	Melville	3,352	Prod. Gas	3	460	A.C	3	300	14	160
25	Nokomis	496	Oil Engines	2	40	D.C	2	24	4¾	
26	Outlook	634	Prod. Gas	1	74	A.C.	1	48	10	48
27	Oxbow	615	Oil Engines	2	50	A.C	2	24	3¼	
28	Radisson	368	Oil Engines	2	34	D.C	2	30	2	23
29	Radville	1,082	Diesel	1	90	A.C	1	50	11	34
30	Rosthern	1,273	Oil Engines	2	80	A.C	2	48	6½	42
31	Saltcoats	424	Prod. Gas	1	[illegible]	A.C	1	37½	3	3
32	Scott	215	Diesel	1	100	A.C.	1	60	3	45
33	Strasbourg	482	Prod. Gas	1	50	A.C	1	30	8	10
34	Unity	747	Oil Engines	2	50	A.C	2	80	3	48
35	Vonda	383	Prod. Gas	1	65	A.C	1	24	3	
36	Wadena	503	Prod. Gas.	1	64	A.C	1	24	4	
37	Wapella	393	Oil Engines	1	25	D.C.	1	12½	2	15
38	Watson	407	Oil Engine	1	15	D.C	1	9	¾	
39	Wilkie	1,041	Oil Engines	2	150	A.C	2	88	8	58
40	Wolseley	944	Prod. Gas and Oil Engines	2	130	A.C	2	100	10	45
41	Wynyard	833	Oil Engine	1	90	A.C	1	50	4½	40
42	Yellowgrass	483	Prod. Gas and Oil Engine	2	115	D.C	2	72	3	30
			Total		5,382			3,171½	200¾	
	Villages									
43	Avonlea	349	Oil Engine	1	25	D.C	1	15	2	13½
44	Elrose	251	Oil Engine	1	25	D.C	1	14	2	11
45	Fillmore	224	Oil Engine	1	25	D.C	1	15	1½	
46	Hawarden	262	Oil Engine	1	25	D.C	1	15	1½	
47	Lake Lenore	178	Oil Engine	1	20		1	10*	½	
48	Leslie	154	Oil Engine	1	15	D.C	1	7½	1	
49	North Regina	540	Current purchased from Regina						3	
50	Viscount	337	Oil Engine	1	25	D.C	1	15	1¼	
51	Wilcox	335	Oil Engines	2	50	D.C	2	30	2	
			Total		210			121½	14¾	

* Estimated

Privately Owned and Operated Plants

	Location	Population 1926	Type of plant	Engines: No of units	Engines: Total capacity H.P	D C or A.C	Generators: No of units	Generators: Total capacity K W	Distribution lines, miles	Maximum peak load K W
52	Aberdeen	320	Oil Engines	2	10	D C	2	6	1	
53	Arcola	685	Oil Engines	2	75	A C	2	40	4½	
54	Balcarres	458	Oil Engines	2	46	D C	2	27	2	24
55	Balgonie	234	Oil Engines	2	45	D C	2	13½	1½	
56	Bengough	362	Oil Engine	1	25	D C	1	15	1*	
57	Biggar	2,034		No return						
58	Briercrest	220	Oil Engine	1	12	D.C	1	7½	½*	
59	Brownlee	153	Oil Engine	1	32	D C	1	20	1	
60	Cabri	494	Oil Engines	2	55	D.C	2	29	2	30
61	Carnduff	537	Oil Engines	3	60	D C	3	41	1	
62	Ceylon	225	Oil Engines	2	30	D C	1	20	1	
63	Coderre	190	Oil Engine	1	16	D.C	1	10	1	
64	Craik	603	Oil Engines	3	110	A C	2	54	6	23
65	Cupar	383	Oil Engines	3	32½	D.C	3	19	4	
66	Duck Lake	587	Oil Engine		15	D C	1	9	2	7
67	East End	420	Oil Engine	1	25	D C	1	15	2	
68	Eyebrow	284	Oil Engine	1	25	D C	1	15	2	11
69	Glenavon	20[illegible]	Oil Engines	2	38	D C	1	10	1	7
70	Gull Lake	908	Prod. Gas	1	64	A C	1	30	3	
71	Herbert	997	Prod. Gas	2	165	A C	2	85	6½	30
72	Hodgeville	220	Oil Engines	3	45	D.C	2	15	1*	9
73	Ituna	434	Oil Engine		20	D C	1	15	1	11
74	Keeler	115	Oil Engine	1	15	D C	1	9	1	
75	Kelliher	3[illegible]0	Oil Engines	2	43	D.C	2	28½	1	16
76	Kerrobert	751		No return						
77	Kipling	442	Oil Engines	2	45	D.C	2	22	1	
78	Lancer	131	Oil Engine	1	15	D.C	1	10	¼*	4
79	Lang.	3[illegible]8	Oil Engines	2	48	D.C	2	37½	2	24
80	Langenburg	258	Oil Engine	1	15	D C	1	[illegible]0	1	8
81	Lashburn	333	Oil Engines	3	68	D.C	3	33	1½	18
82	Lemberg	484	Oil Engine	1	26	A C	1	[illegible]4½	2	10
83	Lloydminster	1,200	Steam.	3	158	D.C	3	117	7	110
84	Loverna	221	Oil Engine	1	15	D.C	1	10	1	

85	Lucky Lake	196	Oil Engines	2	25	D.C	2	12½	¾*	
86	Lumsden	530	Oil Engine	1	40	A.C	1	28	3½	
87	Luseland	304	Oil Engines	2	65	D.C	2	40	3	
88	Macklin	396	Oil Engines	2	30	D.C.	2	15*	1	
89	Maple Creek	930	Steam	2	225	A C	2	160	7	
90	Margo	137	Oil Engine	1	4	D.C	1	1½		
91	Maymont	166		2	15	D.C	2	10	1	
92	Mervin	191	Oil Engine	1	15		1	10*	¾	
93	Milden	195	Oil Engine	1	25	D.C	1	15	1½	
94	Morse	528	Prod. Gas.	1	68	A.C.	1	30	3	
95	Mortlach	394	Oil Engine	1	10	D.C.	1	7½	½	
96	Pelly	257	Oil Engine	1	25	D.C.	1	12½	¾	
97	Perdue	374	Oil Engines	2	40	D.C	2	25	2	
98	Piapot	230	Oil Engine		5	D C	1	3	1	
99	Qu'Appelle	640	Prod Gas Oil Engine	2	135	D.C	2	70	2½	32
100	Raymore	267	Oil Engine	1	25	D.C	1	15	1	12½
101	Readlyn	131	Oil Engines	2	14	D.C	2	6	½	
102	Redvers	193	Oil Engine	1	15	D.C.	1	9	1	9
103	Rosetown	1,142	Oil Engines	3	300	A.C	3	200	3½	85
104	Semans	376	Oil Engines	2	40	D.C.	2	20	2	21½
105	Shaunavon	1,459	Steam	3	450	A.C.	3	270	10¼	140
106	St. Boswell's	162	Oil Engines	2	23	D.C	2	13½	1	11
107	Star City	622	Diese	1	75	A C	1	50	2½	30
108	Summerberry	104	Oil Engine	1	5½	D.C	1	3	1	
109	Sutherland	1,010	Current purchased from Saskatoon.						6	
110	Tisdale	846	Steam	2		A.C	2	175	10	60
111	Tompkins	266	Oil Engines	2	35	D.C	2	22½	1½	17½
112	Tugaske	257	Oil Engines	3		D C	3	36	½	25
113	Tuxford	152	Oil Engines	2	11	D.C	2	6	1	7
114	Vanguard	349	Oil Engines	3	56	D.C	3	35	4½	
115	Vibank	283	Diesel	1	40	D.C.	1	15	2	12
116	Watrous	1,172		No return						
117	Wawota	328	Oil Engine	1	20	D.C.	1	10	¼	6
118	Whitewood	513	Oil Engine	1	25	D.C	1	12½	½	
119	Young	364	Oil Engines	2	35	D.C	2	22½	2	14
			Totals		3,290			2,154½	142½	

*Estimated

Summary

	Total capacity engines H.P	Total capacity generators K.W	Distribution line miles
Municipally owned—			
Cities	58,870	38,310	354¾
Towns	5,382	3,171½	200¼
Villages	210	121½	14¾
Privately owned	3,290	2,154½	142½
Totals.	67,752	43,757½	712¾

APPENDIX No. 2.

SCHEDULE No. 2.

1926 Statistics of Electric Light and Power Plants in the Province of Saskatchewan.

CAPITAL INVESTMENTS

NOTE.—The valuations are in accordance with information supplied but are not necessarily accepted by the Power Resources Commission.

Municipally Owned and Operated Plants

	Name	Total capital investment in plant and distribution system	Debenture indebtedness as at 31st Dec., 1926	Estimated present value: Plant and equipment	Estimated present value: Distribution system	Estimated present value: Total
	Cities					
1	Moose Jaw	$1,109,932	$1,234,722	$800,000	$450,000	$1,250,000
2	North Battleford	232,416	173,400	175,000	130,000	305,000
3	Prince Albert	395,721	296,999	125,033*	120,000*	245,033
4	Regina	2,300,592	1,158,718	986,026	471,120	1,457,146
5	Saskatoon	1,923,532	1,872,887	556,055	585,379	1,141,434
6	Swift Current	425,343	309,584	155,000	30,000	185,000
7	Weyburn	177,354	152,459	130,000	20,000	150,000
8	Yorkton	444,800	332,232	249,176	83,056	332,232
	Totals	$7,010,190	$5,531,001	$3,176,290	$1,889,555	$5,065,845
	Towns					
9	Assiniboia	$ 60,296	$ 18,382	$ 32,130	$ 15,950	$ 48,080
10	Battleford	48,676	10,750	17,247	10,976	28,223
11	Broadview	48,581	14,986	10,000	4,986	14,986
12	Canora	41,000	27,839	25,500*	7,000*	32,500*
13	Carlyle	14,591	8,936	4,635	1,570	6,205
14	Davidson	26,860	22,800	26,860	3,800	30,660
15	Estevan	98,050	68,265	20,000	30,000	50,000
16	Govan	27,168	11,306	18,000	2,000	20,000
17	Grenfell	23,544	9,005	5,500	3,500	9,000
18	Humboldt	61,350	Not stated	76,350	15,000	91,350
19	Indian Head	65,204	38,434	33,000*	10,000*	43,000*
20	Kamsack	115,923	64,683	72,687	16,427	89,114
21	Kindersley	54,533	28,000	19,000	6,000	25,000
22	Langham	12,000	5,839	3,740*	1,000*	4,740
23	Melfort	70,114	36,223	20,880*	13,000*	33,880
24	Melville	112,106	57,660	85,000	27,000	112,000
25	Nokomis	25,000	16,678	12,000	4,000	16,000
26	Outlook	25,500	18,835	15,000	6,000	21,000
27	Oxbow	25,250	15,846	10,500	4,000	14,500
28	Radisson	9,966	3,600	7,614	2,000	9,614
29	Radville	29,000	24,694	23,000	5,000	28,000
30	Rosthern	27,000	17,615	11,000*	9,000*	20,000*
31	Saltcoats	16,100	17,424	10,000*	5,000*	15,000
32	Scott	57,747	Not stated	11,000*	5,000*	16,000
33	Strasbourg	17,497	5,842	6,000	1,000	7,000
34	Unity	45,000	34,167	36,000	9,000	45,000
35	Vonda	19,301	6,664	15,000	3,000	18,000
36	Wadena	20,937	9,490	8,000*	5,000*	13,000*
37	Wapella	8,785	5,371	5,500	1,500	7,000
38	Watson	1,745	None	900	247	1,147
39	Wilkie	40,000	25,370	24,000	4,000	28,000
40	Wolseley	27,667	3,349	Not stated		
41	Wynyard	28,500	26,313	16,500	9,500	26,000
42	Yellowgrass	25,645	9,624	15,000*	5,000*	20,000
	Totals	$1,330,642	$652,950	$697,548	$246,456	$943,999

*Estimated

Municipally Owned and Operated Plants—Continued

	Name	Total capital investment in plant and distribution system	Debenture indebtedness as at 31st Dec., 1926	Estimated present value: Plant and equipment	Distribution system	Total
	Villages					
43	Avonlea	$ 7,700	$ 7,500	$ 5,700*	$ 2,000*	$ 7 700
44	Elrose	8,000	6,500	5,500	2,000	7,500
45	Fillmore	7,600	5,500	5,500*	2,100*	7.600
46	Hawarden	5,300	3,000	2,500*	1,000*	3,500
47	Lake Lenore			1,883	242	2,125
48	Leslie	3,500	1,000	2,000*	1,000*	3,000
49	North Regina	7,105	4,026	No plant	4,203	4,203
50	Viscount	12,149	6,400	4,229	2,693	6,922
51	Wilcox	16,145	6,800	7,500	1,000	8,500
	Totals	$67,499	$40,726	$34,812	$16,238	$51,050

*Estimated.

Privately Owned and Operated Plants

	Name	Total capital investment in plant and distribution system	Debenture indebtedness as at 31st Dec., 1926	Estimated present value: Plant and equipment	Distribution system	Total
	Location					
52	Aberdeen	$ 3,500		$ 2,750*	750*	$ 3,500*
53	Arcola	26,000		13,000*	10,000*	23,000
54	Balcarres.	12,039		9,039*	3,000*	12,039
55	Balgonie	6,397		2,797*	1,500*	4,297
56	Bengough			Not stated		
57	Biggar			No return		
58	Briercrest	3,000		1,600	422	2,022
59	Brownlee	2,200		1,200	1,000	2,200
60	Cabri	14,000		11,500	2,500	14,000
61	Carnduff	11,000		7,000*	1,500*	8,500*
62	Ceylon	7,000		4,000*	1,200*	5,200*
63	Coderre	3,000		1,000	2,000	
64	Craik	23,000		17,000	4,000	21,000
65	Cupar	5,500		5,000*	4,000*	9,000
66	Duck Lake	3,500		1,900	600	2,500
67	Eastend	3,000		1,000	1,000	2,000
68	Eyebrow	3,000		2,000*	1,000*	3.000
69	Glenavon			1,200	700	1.900
70	Gull Lake					
71	Herbert	40,000		23,000	7,000	30,000
72	Hodgeville	6,000		6,000	600	6,600
73	Ituna	5,500		2,500	1,500	4,000
74	Keeler	2,890		1,490*	500*	1,990
75	Kelliher	6,000		5,000	1,000	6,000
76	Kerrobert.			No return		
77	Kipling.	14,000		9,000*	1,500*	10,500*
78	Lancer	3,500		1,500	500*	2,000
79	Lang	8,000		5,600	1,000	6,600
80	Langenburg.	1,500		900	400	1,300
81	Lashburn	7,200		4,000*	2,000*	6,000

*Estimated.

Privately Owned and Operated Plants Continued

	Name	Total capital investment in plant and distribution system	Debenture indebtedness as at 31st Dec., 1926	Estimated present value: Plant and equipment	Estimated present value: Distribution system	Estimated present value: Total
	Location					
82	Lemberg	$ 7,802		$ 3,591	$ 3,430	$ 7,021
83	Lloydminster	56,000		32,000*	13,000*	45,000*
84	Loverna	2,300		1,650	350	2,000
85	Lucky Lake					
86	Lumsden			Not stated	3,500	3,500
87	Luseland	12,500		10,000	2,500	12,500
88	Macklin					
89	Maple Creek	40,000		9,137*	4,000*	13,137
90	Margo	250		250	200	450
91	Maymont	4,500		3,000	500	3,500
92	Mervin					
93	Milden	4,500		3,500	1,000	4,500
94	Morse	15,000*		10,000	5,000	15,000
95	Mortlach	5,200*		2,500	2,700	5,200
96	Pelly	8,444		3,180	1,348	4,528
97	Purdue	11,000		8,500	2,500	11,000
98	Piapot	3,500		2,000	500	2,500
99	Qu'Appelle	21,000		8,500	4,000	12,500
100	Raymore	4,500		3,500	800	4,300
101	Readlyn	1,925		750*	250*	1,000
102	Redvers	3,000		2,250*	1,200*	3,450
103	Rosetown	55,000		29,500	10,000	39,500
104	Semans	12,000		8,000	2,000	10,000
105	Shaunavon	31,937		18,499	13,438	31,937
106	St. Boswells	2,200		1,500*	500*	2,000*
107	Star City	18,480		11,108*	4,000*	15,108
108	Summerberry	2,000		1,500	200	1,700
109	Sutherland	13,500		No plant	13,500	13,500
110	Tisdale	50,000		35,000	10,000	45,000
111	Tompkins	8,500		6,000	2,000	8,000
112	Tugaske	3,500		2,500*	500*	3,000
113	Tuxford	3,500		2,250*	750	3,000
114	Vanguard	5,000		3,500*	1,500*	5,000
115	Vibank	7,000		5,000*	2,000*	7,000
116	Watrous			No return		
117	Wawota	2,381		2,140	241	2,381
118	Whitewood			Not stated		
119	Young	9,000		7,500	1,500	9,000
	Totals	$649,745		$379,281	$160,079	$539,360

*Estimated.

SUMMARY

Municipally owned					
Cities	$7,010,190	$5,531,001	$3,176,290	$1,889,655	$5,065,845
Towns	1,330,642	652,980	697,543	246,456	943,999
Villages	67,499	40,726	34,812	16,238	51,050
Privately owned	649,745		379,281	160,079	539,360
Totals	$9,058,076	$6,224,707	$4,287,926	$2,312,328	$6,600,254

APPENDIX No. 2.

SCHEDULE No 3.

1926 Statistics of Electric Light and Power Plants in the Province of Saskatchewan

REVENUE AND EXPENDITURE

Municipally Owned and Operated Plants

	Name	Total output in 1926 K.W.H	Total expenditure in 1926	Total revenue in 1926	Average expenditure per K.W.H. output cents	Average revenue per K.W.H output cents
	Cities					
1	Moose Jaw	12,752,312	$312,991 61	$412,999 79	2 45	3 24
2	N Battleford	1,260,814	81,117 .05	76,855 .57	6 .43	6 10
3	Prince Albert	3,174,783	109,775 01	128,122 56	3 46	4 04
4	Regina	24,620,050	445,647 .83	672,481 .84	1 .82	2 74
5	Saskatoon	19,256,960	499,421 46	618,019 .31	2 59	3 21
6	Swift Current	1,257,400	66,410 00	87,304 81	5 28	6 94
7	Weyburn	1,006,964	49,231 18	68,876 67	4 89	6 84
8	Yorkton	716,774	73,560 73	75,844 91	10 26	10 54
	Totals.		$1,638,154 87	$2,140,505 46		
	Towns					
9	Assiniboia	167,623	$15,078 83	$21,795 80	8 99	13 00
10	Battleford	135,840	11,884 45	13,662 23	8 75	10 .06
11	Broadview	42,268	10,288 37	8,866 47	24 37	20 97
12	Canora	94,268	9,817 71	11,854 85	10 41	12 57
13	Carlyle	16,080	6,076 41	4,631 22	31 85	24 27
14	Davidson	102,263	9,258 17	9,350 00	9 05	9 13
15	Estevan	702,888	33,397 27	41,618 77	4 75	5 92
16	Govan	26,048	6,483 52	6,523 05	24 39	25 04
17	Grenfell	50,000*	8,224 12	7,197 57		
18	Humboldt	384,349	27,542 96	32,725 98	7 17	8 .52
19	Indian Head	156,580	20,317 70	21,459 .02	12 97	13 71
20	Kamsack	494,199	30,.48 95	39,330 80	6 10	7 96
21	Kindersley	151,920	11,827 42	18,267 01	7 79	12 02
22	Langham	24,651	5,399 23	4,748 50	21 90	19 26
23	Melfort	339,621	25,310 41	34,237 66	7 45	10 08
24	Melville	304,950	35,280 37	38,112 88	11 57	12 49
25	Nokomis	39,520	7,620 65	6,801 45	19 28	17 21
26	Outlook	56,200	8,756 18	8,610 .55	15 57	15 .32
27	Oxbow	28,596	7,350 26	5,871 52	31 15	24 88
28	Radisson	24,550	5,149 22	6,138 .38	20 97	25 .00
29	Radville	41,416	7,401 90	8,674 79	17 .87	20 94
30	Rosthern	68,895	10,318 31	10,756 17	14 95	15 60
31	Saltcoats	18,800	5,407 .34	3,445 .20	28 78	18 .32
32	Scott .	34,200	3,839 19	3,406 25	11 22	9 96
33	Strasbourg	30,900	5,437 51	5,749 .30	17 .59	18 61
34	Unity	72,460	11,544 10	11,470 67	15 90	15 83
35	Vonda	23,949	5,850 98	6,306 70	24 43	26 34
36	Wadena	35,000	6,510 .41	5,747 20	18 58	16 .43
37	Wapella	17,500*	3,.62 87	3,115 76	18 06*	17 80*
38	Watson	6,113	1,457 .76	1,384 05	23 .85	22 .64
39	Wilkie .	93,832	11,722 .05	11,809 02	12 56	12 65
40	Wolseley	75,730	7,141 46	9,099 58	9 43	12 01
41	Wynyard	51,800	8,301 84	10,131 57	16 03	19 56
42	Yellowgrass. .	44,600	8,423 82	8,493 62	18 90	19 04
	Totals		$391,728 74	$441,393 87		

*Estimated.

Municipally Owned and Operated Plants Continued.

	Name	Total output in 1926 K.W.H.	Total expenditure in 1926	Total revenue in 1926	Average expenditure per K.W.H. output cents	Average revenue per K.W.H. output cents
	Villages					
43	Avonlea 3 mos.	4,381	$ 849 00	$1,207 00		
44	Elrose 2 mos.	2,550				
45	Fillmore	7,000*				
46	Hawarden	5,000*	1,000 00	1,890 00		
47	Lake Lenore	4,500*				
48	Leslie	400				
49	North Regina	22,320	Current purchased from Regina.			
50	Viscount	10,000*	3,341 98	2,914 95		
51	Wilcox	15,443	4,434 53	4,089 60	28 72	26 48
	Totals		$9,425 51	$10,101 55		

*Estimated

Privately Owned and Operated Plants

	Name	Total output in 1926 K.W.H.	Total expenditure in 1926	Total revenue in 1926	Average expenditure per K.WH. output cents	Average revenue per K.W.H. output cents
	Location					
52	Aberdeen					
53	Arcola	40,000	$4,145 00	$7,550 00	10 36	18 87
54	Balcarres	20,100	3,437 99	6,277 39	17 10	31 23
55	Balgonie	7,509	1,153 70	1,632 10	15 36	21 74
56	Bengough					
57	Biggar					
58	Briercrest	7,000	2,676 44	2,400 00	38 23	34 28
59	Brownlee					
60	Cabri					
61	Carnduff					
62	Ceylon					
63	Coderre					
64	Craik	22,000	5,344 00	5,770 00	24 29	26 23
65	Cupar	15,721	2,947 25	4,170 25	18 75	26 53
66	Duck Lake	5,100		1,461 50		28 66
67	Eastend					
68	Eyebrow	12,650				
69	Glenavon					
70	Gull Lake					
71	Herbert	56,311	8,253 94	9,898 19	14 66	17 58
72	Hodgeville					
73	Imma	7,700	2,135 37	2,237 16	27 73	29 06
74	Keeler		2,187 13	2,220 20		
75	Kelliher		2,775 00	3,879 20		
76	Kerrobert					
77	Kipling	16,980	2,835 17	4,489 70	16 70	26 49
78	Lancer	4,300		1,200 00		
79	Lang	21,000	2,795 00	4,885 00	13 31	23 02
80	Langenburg					
81	Lashburn	24,651	5,399 23	4,748 59	21 90	19 26

*Estimated.

Municipally Owned and Operated Plants—Continued.

	Name	Total output in 1926 K W.H.	Total expenditure in 1926	Total revenue in 1926	Average expenditure per K W H output cents	Average revenue per K W H output cents
	Location					
82	Lemberg	7,510	$ 1,608 26	$ 2,261 30	21 42	30 11
83	Lloydminster		15,958 96	22,936 59		
84	Loverna	6,000	1,582 68	1,500 00	26 37	25 00
85	Lucky Lake.					
86	Lumsden					
87	Luseland	15,000				
88	Mackur					
89	Maple Creek.		13,702 .65	15,081 75		
90	Margo					
91	Maymont					
92	Mervin					
93	Milden					
94	Morse	25,000	7,931 49	6,642 00	3. 72	26 57
[illegible]	Mortlach					
96	Pelly	10,000	2,190 96	2 482 06	21 91	24 82
97	Perdue					
98	Piapot					
99	Qu'Appelle	28,000	2,720 00	6,050 00	9 72	21 61
100	Raymore	11,266	1,525 00	3,079 .00	13 54	27 42
101	Readlyn	2,293	667 50	1,032 00	29 11	45 00
102	Redvers	6,041	1,513 45	2,164 00	25 .05	35 82
103	Rosetown	160,448	16,281 .36	22,050 40	9 52	13 74
104	Semans	25,000	5,530 55	5,388 49	22 12	21 56
105	Shaunavon	363,105	22 162 25	32,233 11	6 10	8 88
106	St. Boswells.	5,013	1,279 00	1,346 81	25 51	26 87
107	Star City	41,726	6,000 00	6,000 .00	14 .38	14 38
108	Summerberry		452 05	6,3 00		
109	Sutherland	11,580	1,193 22	1,924 71	10 30	16 62
110	Tisdale	78,160				
111	Tompkins	.4,000	2,392 25	3,120 00	.7 09	22 28
112	Tugaske	6,100	1,395 00	1 947 90	22 87	31 93
113	Tuxford		1,877 90	3,055 79		
114	Vanguard	8,150				
115	Vibank		1,862 .45	1,837 45		
116	Watrous					
117	Wawota					
118	Whitewood					
119	Young	15,000		4,000 .00		26 66
	Totals		$154,912 20	$209,515 64		

*Estimated

Summary

	Total expenditure in 1926	Total revenue in 1926
Municipally owned		
Cities	$1,638,154 87	$2,140,505 46
Towns	391 728 74	441,398 87
Villages	9,425 51	10,101 55
Privately owned plants	154,912 20	209,515 64
Totals	$2.194,221 32	$2,801,516 52

APPENDIX No. 2

SCHEDULE No. 4

1926 Statistics of Electric Light and Power Plants in the Province of Saskatchewan

Municipally Owned and Operated Plants

	Name	Population	No. of consumers	Total output in 1926 K.W.H.	Average output per consumer K.W.H.	Average output per head of population K.W.H.
	Cities					
1	Moose Jaw	19,039	5,333	12,752,312	2,391	670
2	North Battleford	4,787	982	1,260,814	1,284	263
3	Prince Albert	7,873	1,900	3,174,733	1,670	403
4	Regina	37,329	10,629	24,520,650	2,307	657
5	Saskatoon	31,234	9,526	19,258,980	2,021	617
6	Swift Current	4,175	1,389	1,257,400	906	302
7	Weyburn	4,119	877	1,006,964	1,148	244
8	Yorkton	4,468	1,102	716,774	650	161
		112,014	31,738	63,946,627		
	Towns					
9	Assiniboia	1,245	355	167,623	472	134
10	Battleford	1,018	230	135,340	591	133
11	Broadview	781	181	42,268	233	54
12	Canora	1,121	200	94,268		
13	Carlyle	388	98	15,080	154	39
14	Davidson	602	155	102,263	660	170
15	Estevan	2,336	622	702,888	1,129	301
16	Govan	456	111	26,048	234	57
17	Grenfell	699	198	50,000*	252*	72*
18	Humboldt	1,751	420	384,349	915	219
19	Indian Head	1,318	360	156,580	435	118
20	Kamsack	1,948	430	494,199	1,148	253
21	Kindersley	987	248	151,920	610	154
22	Langham	416	83	24,651	297	59
23	Melfort	1,605	431	339,621	788	211
24	Melville	3,352	585	304,950	521	91
25	Nokomis	496	114	39,520	346	79
26	Outlook	634	182	56,200	308	88
27	Oxbow	615	124	23,596	190	38
28	Radisson	368	96	24,550	255	66
29	Radville	1,082	172	41,416	240	38
30	Rosthern	1,273	225	68,805	306	54
31	Saltcoats	424	109	18,800	172	44
32	Scott	215	53	34,200	645	159
33	Strasbourg	482	145	30,900	213	64
34	Unity	747	192	72,460	377	97
35	Vonda	383	99	23,949	242	62
36	Wadena	503	140	35,000	250	69
37	Wapella	393	70	17,500*	250*	44*
38	Watson	407	20	6,113	305	15
39	Wilkie	1,041	233	93,332	400	89
40	Wolseley	944	228	75,730	332	80
41	Wynyard	833	174	51,800	297	62
42	Yellow Grass	483	127	44,600	350	92
	Totals	31,846	7,210	3,951,109		

*Estimated

Municipally Owned and Operated Plants—Continued.

	Name	Population	No. of consumers	Total output in 1926 K.W.H.	Average output per consumer K.W.H.	Average output per head of population K.W.H.
	Villages					
43	Avonlea	349	60	4,381 (3 months)		
44	Elrose	251	58	2,550 (2 months)		
45	Fillmore.	224	45			
46	Hawarden	262	32			
47	Lake Lenore	178	29			
48	Leslie	154	28			
49	North Regina	540	100	22,320	223	41
50	Viscount	337	60*			
51	Wilcox	335	81	15,443	190	46
	Totals.	2,630	493	44,694		

*Estimated.

Privately Owned and Operated Plants

	Location					
52	Aberdeen	320	16	4,000*		
53	Arcola	685	140	40,000	286	58
54	Balcarres	458	109	20,100	184	44
55	Balgonie.	234	30	7,509	250	32
56	Bengough	362	30	7,500*		
57	Biggar	2,034				
58	Briercrest.	220	42	7,000	166	31
59	Brownlee	153	35	10,000*		
60	Cabri	497		15,000*		
61	Carnduff	537	104	25,000*		
62	Ceylon	225		12,000*		
63	Coderre	190	22	5,000*		
64	Craik	603	96	22,000	229	36
65	Cupar	383	88	15,721	178	41
66	Duck Lake	587	31	51,000	164	8 7
67	Eastend.	420	70	13,000*		
68	Eyebrow	284	73	12,650	173	44
69	Glenavon	201	23	5,000*		
70	Gull Lake	908	198	50,000*		
71	Herbert	997	167	56,3.1	337	56
72	Hodgeville	220	40	8,000*		
73	Ituna	434	60	7,700	154	17
74	Keeler	115	29	7,500*		
75	Kelliher	310	53	15,000*		
76	Kerrobert	751				
77	Kipling.	442	80	16,980	212	38
78	Lancer	131	20	4,800	240	36
79	Lang.	318	90	21,000	233	66
80	Langenburg.	288	10	3,000*		
81	Lashburn	333	94	24,651	262	74
82	Lemberg	484	65	7,510	115	15
83	Lloydminster.	1,200	355	100,000*		
84	Loverna	221	35	6,000	171	27
85	Lucky Lake	196	30	9,000*		
86	Lumsden	530	135	40,000*		
87	Luseland	304	75	15,000	200	49
88	Macklin	398		7,500*		
89	Maple Creek	980	260	85,000*		
90	Margo	137	5	1,000*		
91	Maymont.	166	-	5,000*		

*Estimated.

Privately Owned and Operated Plants—Continued

	Name	Population	No. of consumers	Total output in 1926 K.W.H.	Average output per consumer K.W.H.	Average output per head of population K.W.H.
	Location					
92	Mervin	191		5,000*		
93	Milden	196	46	12,000*		
94	Morse	528	102	25,000	245	47
95	Mortlach	394	7	3,000*		
96	Pelly	257	50	10,000	200	39
97	Perdue	374	71	20,000*		
98	Piapot	230	20	3,000*		
99	Qu'Appelle	640	115	28,000	243	43
100	Raymore	267	62	11,266	181	42
101	Readlyn	131	8	2,293	287	17
102	Redvers	193	32	6,041	188	31
103	Rosetown	1,142	286	160,448	561	140
104	Semans	376	131	25,000	190	66
105	Shaunavon	1,459	560	363,105	649	249
106	St. Boswells	162	33	5,013	151	31
107	Star City	622	103	41,726	405	67
108	Summerberry	104	30	5,000*		
109	Sutherland	1,010	164	11,580	70	11
110	Tisdale	846	200	78,160	390	92
111	Tompkins	266	68	14,000	206	52
112	Tugaske	257	38	6,100	160	23
113	Tuxford	152	43	8,000*		
114	Vanguard	349	36	8,150	226	23
115	Vibank	283	65	15,000*		
116	Watrous	1,172		No return.		
117	Wawota	328	10	4,000*		
118	Whitewood	513		8,000*		
119	Young	364	60	15,000	250	41
	Totals	31,009	5,030	1,611,414		

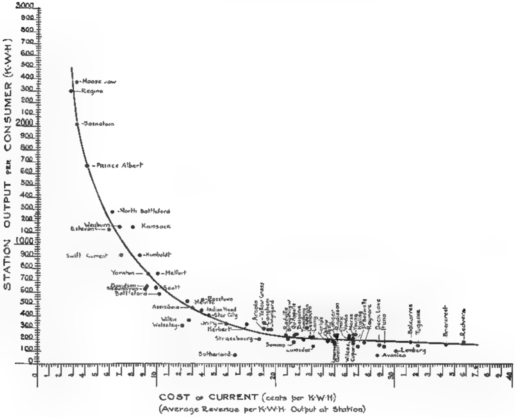
*Estimated.

Summary

	Population	No. of consumers	Total output in 1926 K.W.H.
Municipally owned plants:			
Cities	113,014	31,738	63,946,627
Towns	31,346	7,210	3,951,109
Villages	2,630	493	44,694
Privately owned	31,009	5,030	1,611,414
Totals	177,999	44,471	69,553,844

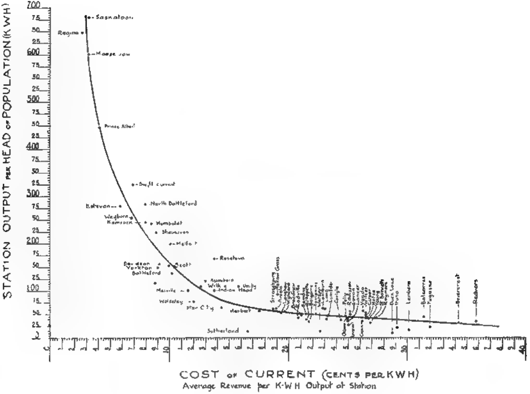
APPENDIX № 3

CHART SHOWING THE RELATION BETWEEN AVERAGE COST OF CURRENT AND THE AVERAGE CONSUMPTION PER CONSUMER



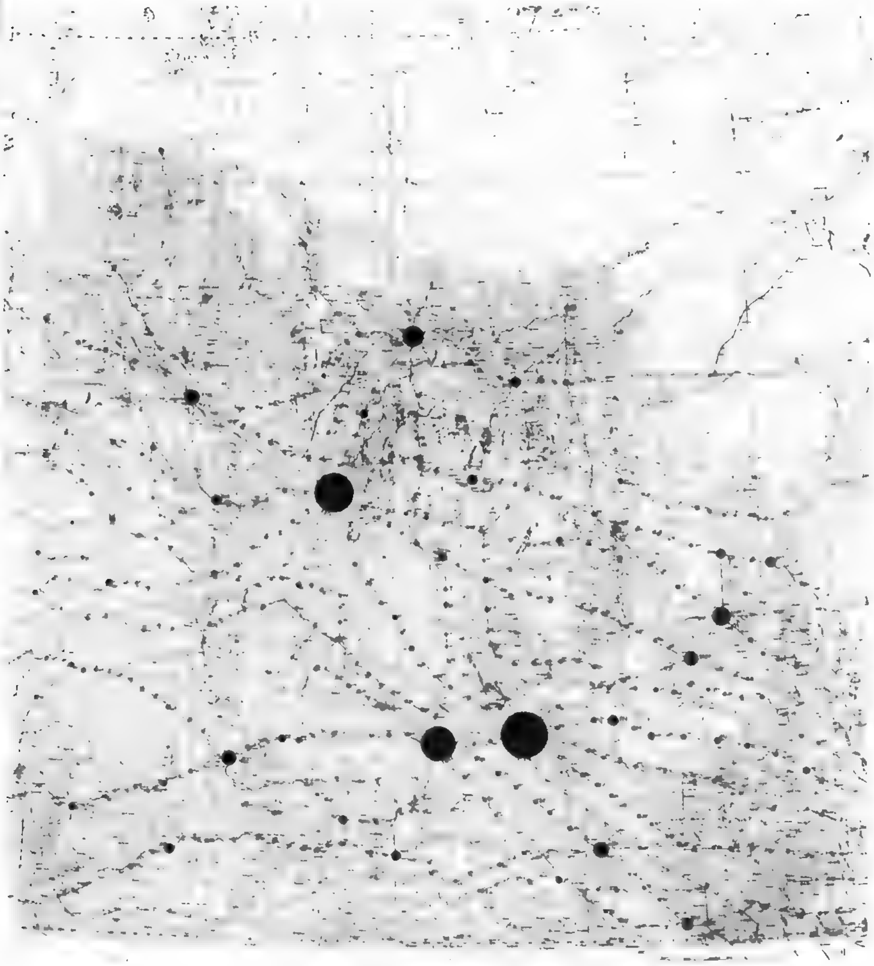
APPENDIX No 4

CHART SHOWING THE RELATION BETWEEN AVERAGE COST OF CURRENT AND THE AVERAGE CONSUMPTION PER HEAD OF POPULATION



APPENDIX No. 5

MAP OF SOUTHERN PART OF SASKATCHEWAN SHOWING POPULATION OF CITIES, TOWNS AND VILLAGES



APPENDIX No. 6

Comparative Costs of Transmitting Power from the Souris Coal Field to Regina

By R. N. Blackburn, M.E.I.C.

Power Resources Commission,

Gentlemen

In accordance with your instructions I have investigated the relative costs of generating power at the mines at Bienfait and transmitting the same to Regina electrically, as compared with the cost of transhipping the coal from Bienfait to Regina and generating electric power with Souris coal in a power station at Regina.

As relative costs only are required, the problem may be simplified by omitting from consideration those costs which would be the same in each case. It may be assumed that the capital cost of the power station, cost of operation, depreciation and maintenance, would be the same in each case. Also that the thermal efficiency of the plant, that is the number of pounds of Souris Lignite coal required to generate one K.W.H. would be the same in Regina as at the mine. It is only necessary, therefore in the present instance to compare the freight charges from Bienfait to Regina on the amount of coal required to generate one K.W.H. with the cost of transmitting one K.W.H. electrically.

The fuel consumption at the Regina municipal power plant in 1926 was 1.387 lbs. of Crow's Nest Pass coal per K.W.H. generated. The calorific value of this coal averages about 14,000 B.T.U. per pound and the average heat consumption of the station per K.W.H. in 1926 was 19,390 B.T.U. per K.W.H. delivered at the switchboard. In this connection it may be noted that while some modern plants show a higher thermal efficiency than this, it will usually be found that these plants are operating at a higher load factor than the Regina plant and it may be stated that the Regina plant shows a comparatively high thermal efficiency for the load factor at which the plant is operated.

The consumption of Souris Lignite coal per K.W.H. would obviously be higher than the consumption of Crow's Nest Pass coal, since the calorific value of Souris Lignite coal per pound is considerably lower than that of Crow's Nest Pass coal. The calorific value of Souris coal is about 10,500 B.T.U. per pound on a dry basis, but as the coal after being taken out of the mine and slightly air-dried usually contains from 31 to 32 per cent. of moisture the actual calorific value of the fuel as received at the plant is only about 7,120 B.T.U. per pound. In burning this coal in a boiler furnace, some of the heat value of the coal is expended in evaporating the contained moisture and as this part of the calorific value of the coal is not available for raising steam the average *available* heat value may be taken at about 6,744 B.T.U. per pound. From

these considerations it is evident that taking the average performance of the Regina municipal plant as a basis, the fuel consumption of Souris coal would be 2.88 pounds of coal per K.W.H. delivered at the switchboard, but as the thermal efficiency of the boilers and furnace would be a little lower with Souris coal than with Crow's Nest Pass coal on account of the lower furnace temperatures it may be assumed that about 3 lbs. of Souris coal would be required to generate one K.W.H. under similar conditions to the Regina municipal plant.

The freight rate on Souris coal from Bienfait to Regina is $1.90 per ton, so that the freight charges on the amount of coal required to generate one K.W.H. is 0.285 cents.

This cost will now be compared with the cost of transmitting one K.W.H. electrically.

Important factors in the cost of transmitting power electrically are the amount of power transmitted, and also the variation in demand (that is the power factor). The total electrical output of the Regina municipal plant during recent years was as follows:

Year	Annual output K.W.H.
1922	17,308,750
1923	18,384,710
1924	18,839,075
1925	21,373,905
1926	24,520,850

It will be noted that the annual output in 1926 showed an increase over the output in 1922 of about 42 per cent., so it would appear desirable that the transmission line should be capable of transmitting at least 50 per cent. more power per annum than the electrical output of the Regina plant in 1926. It is assumed that an annual transmission of about 38,900,000 K.W.H. per annum will be required in 1930, and the comparison is made, therefore, on this basis.

The present average monthly load factor of the Regina plant is about 51 per cent., varying from 47.06 per cent. in February, 1926, to 55.94 in July, 1926. As, however, the average winter peak load is considerably higher than the summer peak load, the *annual* load factor would be less than the monthly average. The maximum peak load during 1926 appears to have been approximately 8,000 K.W.H. (on December 22, 1926), and from this it would appear that the yearly load factor is about 36.9 per cent. With the increased electrical consumption in Regina in 1930, an increase in the load factor may reasonably be anticipated, and for the purpose of this comparison a load factor of 45 per cent. is assumed, which corresponds to a maximum peak load of nearly 10,000 K.W.

The mines at Bienfait are 90 miles to the south and 82 miles to the east of Regina, so that the direct distance from Regina to the mines is 121.6 miles. In order to allow for some deviation from the most direct route, the transmission distance is taken at 130 miles. An appropriate transmission voltage for this distance would be 110,000 volts, and it is assumed that 3-phase, 60-cycle current would be used for transmission. A power factor of 80 per cent.

is assumed, and a space of 10 feet between the transmission cables. It is assumed that No 0 bare copper transmission lines will be used (or its equivalent, No. 000 steel reinforced aluminum cable), having a resistance of 0.5087 ohms per mile. With a load of 10,000 K.W and 80 per cent power factor, the current per wire would be 75.5 amperes. The reactance per mile would be 0.83 ohms

The voltage regulation of such a line figures out at 14 per cent., and the efficiency of transmission at 90.3 per cent, the loss in transmission thus being 9 7 per cent

The cost of a transmission line with steel towers at 880 feet spacing is estimated at $7,590 per mile, as follows

Steel towers.	$4,000
Conductors	1,100
Insulators, ground cable, etc.	500
Labour	1,000
Engineering, supervision, etc.	300
Contingencies 5%, Contractor's profit 5%	690
Total cost	$7,590 per mile

The annual charges on the above transmission line are estimated at $654.88 per mile:

Interest 5%	$379 50
Sinking Fund, 30 years at 4%	135 38
Maintenance and patrol	140 00
Total annual charge	$654 88 per mile

As an alternative to the above, the capital cost and annual charges on a wood pole transmission line of comparatively cheap construction, may be considered. The conductor supports would be of standard "H" construction, each support consisting of two-40-foot vertical poles with a 20-foot cross arm. The supports would have 220 feet spacing, which would give 24 supports per mile. About four times as many insulators would be required as would be necessary with steel towers. The cost of a wood pole line is estimated at $5,250 per mile, as follows

Poles, cross arms, fittings, anchors, etc..	$1,173
Conductors	1,100
Insulators	1,600
Labour	600
Engineering, supervision, etc.	300
Contingencies 5%, Contractor's profit 5%	477
Total cost..	$5,250 per mile.

The life of wood poles would be considerably shorter than that of steel towers, and in computing the annual charges the average life of a wood pole line is taken at 18 years. On this basis, the annual charges would amount to $626 67 per mile, thus.

Interest 5%.	$ 262 50
Sinking Fund, 18 years at 4%	204 17
Maintenance and patrol	160 00
Total annual charges per mile	$ 626 67

From the above it is evident, that although the initial cost of a wood pole transmission line would be lower than that of a

transmission line with steel tower supports, there would be very little difference in the total annual charges of the two transmission lines.

Step-up transformers would be required at the generating end of the line, and a step-down sub-station at Regina. The cost of these, with transformers, switches, bus structures, etc. is estimated at $300 000. The annual charges on the transformer stations would be:

Interest 5%	$15,000 00
Sinking Fund, 25 years at 4%	7,203 00
Maintenance and operation 1½%	4,500 00
Total annual charges	$26,703 00

The total annual charges on the transmission system would, therefore, be as follows:

Annual charges on 130 miles of transmission line at $626.67 per mile	$81,467 10
Annual charge on transformer stations	26,703 00
Total annual charges on transmission system	$108,170 10

For an annual transmission of 38,900,000 K W H. the cost of transmission would thus be $108,170 10, which is equivalent to a transmission cost of 0.278 cents per K W H. This may be compared with 0 285 cents, the freight charge on the Souris coal required to generate one K W H. at Regina. The above investigation shows, therefore, an apparent advantage of 0.007 cents per K W H. in favor of electrical transmission.

Against this, however, must be set the loss of 9 7 per cent. of energy in transmission, which on the basis of a coal consumption of 3 lbs. of Souris coal per K W H. at $1.50 per ton, is equivalent to an additional cost of 0.022 cents per K W H., making the total cost of transmission including line losses, equal to 0.300 cents per K W H., as compared with 0 285 freight charges.

If the City of Moose Jaw were also included in a power transmission scheme, it is readily apparent that the relative costs of power transmission and freight charges on Souris coal would not be materially changed. The total power transmitted per annum would be increased by about 52 per cent., but the annual charges on transformer stations would also be increased in practically the same ratio, also larger conductors would be required and about 42 additional miles of transmission line would require to be built to connect with Moose Jaw, so that net costs per K W H. would be nearly the same.

There would be a market for a certain amount of power in Weyburn and other towns along the transmission line, but the amount of power thus disposed of en route would be too small to materially affect the above comparison. The total amount of current used in the five principal towns along the line in 1926 was less than 5 per cent. of the power used in Regina alone, and less than 3½ per cent. of the combined output of the plants at Regina

and Moose Jaw. In order to supply these towns, additional sub-stations would be required, which on account of the high transmission voltage would be comparatively costly, and the annual charges on these sub-stations would, of course, have to be provided for.

A serious objection to a scheme of electrical transmission over a single line would be the possibility of interruptions in service due to line breakdowns, lightning, etc. If a complete transmission network were established throughout the southern part of the province, so that power could be transmitted over several alternative routes, the probability of interruptions in service would be considerably reduced and might be practically eliminated, but under the assumed conditions of a single transmission line, the Regina civic authorities would probably insist on the present Municipal Plant being maintained as a stand-by plant, and if the annual charges on this plant, together with the cost of maintaining it under steam at all times so that it could be put on the line at very short notice, were charged against the electric transmission system, it would appear that a scheme of this kind would not be economically practicable at the present time. Even if the Regina municipal power plant were entirely closed down, provision would still have to be made for the redemption of the capital invested in the existing plant.

It should be pointed out, however, that although a scheme of electrical transmission of power from the southern coal field to Regina and Moose Jaw is not economically attractive at the present time, it by no means follows that it will always remain so. A sufficient increase in the power consumption of these two cities would very materially alter the conditions and might make a power transmission scheme economically desirable, and at the present rate of increase, the date when sufficiently favorable conditions will obtain cannot be very far distant. The cost of transmission per K.W.H. would be considerably reduced by a sufficient increase in load, since it is evident that for a very substantial increase in load, the only increase in transmission line construction costs will be that due to the increased size of conductors, as the cost of the towers (or poles), insulators, etc., would remain substantially the same for a comparatively large increase in load.

The load factor (i.e., the ratio of the average load to the maximum load), is also a very important item in the cost of transmitting power electrically, the cost varying nearly inversely proportionately to the load factor. It may be noted, therefore, that if the load factor could be increased from 45 per cent. to say 70 per cent., the cost of transmission would be reduced from 0.3 cents per K.W.H. to approximately 0.2 cents per K.W.H., and the advantage of transmitting the power electrically would be apparent. This consideration points to the advisability of establishing a base-load station at the coal fields as soon as the power consumption increases sufficiently to warrant it. This station would be operated at a load factor as near unity as possible, the additional loads due to the daily peaks being carried by local stations in the cities.

The possibility of locating a central power plant on the Saskatchewan coal field at a point nearer to the present centre of the load, may also be mentioned There are considerable coal deposits at Lake-of-the-Rivers at a point distant about 40 miles from Moose Jaw and about 70 miles from Regina, and if these deposits are found upon investigation to be suitable for a power station fuel supply, the establishment of a base-load station at or near this point presents possibilities for their future utilisation

Your obedient servant,

R. N BLACKBURN

15th June, 1927.

APPENDIX No. 7

Saskatchewan Lignite Fields in Their Relation to Establishment of Central Power Stations

By W. H. Hastings.

The coal reserve of Saskatchewan has been estimated by Dowling (1) to be approximately sixty-five billion tons, all lignite. Development has taken place over a wide area, extending from Estevan in the east, to Eastend in the west. Fifty-six mines were operated in the province in 1926 and produced 451,077 tons of coal. Ninety per cent. of the total production of the province comes from eight large mines in the Estevan field. A large proportion of the smaller mines do not ship coal, but take care of the local domestic fuel requirements.

The Estevan Field

In the Estevan field a number of well equipped mines are in operation and produce over 400,000 tons of lignite annually. The output of the various mines drops off materially in the summer months, owing to the poor storing qualities of the coal, so that the actual capacity of the mines is at least double the present production figure of 400,000 tons.

It would appear that in this district a central power station would have available an unlimited supply of coal, and that the mines already in operation could supply the plant with half a million tons annually, and at the same time take care of the present domestic market.

The Willowbunch-Wood Mountain Coal Area

The coal seams of the area were mapped in 1915 by Bruce Rose (2) of the Dominion Geological Survey. The contents of the report would indicate that the area contains an adequate supply of mineable lignite for power purposes. The following is quoted from Rose's report: "The area is abundantly supplied with lignite coal of good quality, and can be used for heating purposes locally, while tests show it to be a good gas producer. It may, then, be counted as a power reserve for manufacturing."

"The lignite occurs in flat-lying beds interstratified with clays, sands and shales. The beds vary in thickness from one to twenty feet. Out-crops are found along the sides of coulees and abandoned river channels."

A small amount of mining has taken place in the area for a good many years past. In 1926, seven thousand tons of coal were mined for local domestic consumption.

Cypress Hills Coal Area

Some thin seams of coal outcrop in the Frenchman River Valley in the vicinity of Eastend and Shaunavon. A thousand tons of coal were mined for local consumption from these seams in 1926.

The three areas referred to above may be considered to possess sufficient mineable coal within easy reach of transportation to supply the needs of a power station of any dimensions.

(1) "Memoir No. 59 Coal Fields and Coal Resources of Canada," Dowling, Dominion Geological Survey

(2) "Wood Mountain-Willowbunch Coal Area," by Bruce Rose, Memoir 89, Department of Mines. Ottawa, 1916

Coal Formations and Outcrops Lying Outside the Present Producing Areas

In addition to the three main lignite areas mentioned, outcrops and indications of coal have been found spread over a wide area in the southern and western portions of the province. Owing to location, off transportation, the absence of outcrops indicating the extent of the seams and other causes very little development has taken place.

I.—Cretaceous Coals, Belly River Formation

A coal formation known as the Belly River Formation underlies a large area in the western portion of the province, extending from Unity in the north, to a point south of Maple Creek.

Lignite seams in this formation have been discovered in well borings or river valleys as follows

Unity	4′ seam
Kerrobert	2′ seam
Brock	8′ seam under 130 ft. cover
Maple Creek.	4′ seam under 195 ft. cover
Maple Creek.	7′ seam under 296 ft. cover
Saskatchewan Landing	5′ seam
South-east of Swift Current.	5′ seam under 75 ft. cover

II. The Underlying Seams of the Souris Coal Field

All of the coal mined in the Estevan field comes from seams lying within one hundred feet of the surface. Between 100 feet and 600 feet there are several other seams. As the coal measures rise towards the north, these lower seams should be found near the surface in that direction, and probably do outcrop, but owing to the heavy mantel of drift they are not exposed. The outermost locations showing the presence of coal thought to represent the lower Estevan seams have been reported as follows

Near Cullen, 16 feet coal, 45 feet cover
Near Arcola, 14 feet coal.
Near Wauchope, 8 feet coal, 350 feet cover
Near Stoughton, 20 feet coal, 120 feet cover
Near Halbrite, 7 feet coal.

The coal seams near Halbrite are badly shattered and greatly disturbed. A small amount of mining has taken place, but not in recent years.

III.—Coal Outcrops to the North of Wood Mountain-Willowbunch Coal Area

A northwesterly trending arm of the Wood Mountain plateau including the Dirt Hills and the Missouri coteau passes west of Moose Jaw, and extends some distance north of the South Saskatchewan River. The plateau is composed of tertiary rocks and is coal bearing.

The finding of coal in this area is described in Summary Report of the Geological Survey, Department of Mines, for the year 1913, and reads as follows:

"West of Avonlea, a 7-foot seam is reported from a well boring at a depth of 70 feet in section 24, township 12, range XXIV, west of second meridian, a seam 2 to 3 feet thick has been dug for local use. This is just at the escarpment of the Coteau du Missouri, where the dirt hills face the level prairie to the east. Small seams of lignite are reported to be common in the disturbed strata of the escarpment. Farther west and well within the area of the Dirt Hills in section 29, township 11, range XXV, west of second meridian, a 3-foot seam outcrops in a small coulee."

"Near Grace, Saskatchewan, in section 36, township 10, range XXVIII, west of second meridian, the Consumers Coal Co., of Moose Jaw, Saskatchewan, have carried on the largest mining operations of any place visited. Here a 7-foot seam outcrops in the coulee occupied by Lake-of-the-Rivers. It rests on clay and is followed upwards by a series of clays and thin lignite seams. Several hundreds of tons were mined and used locally. Then a fault was encountered and mining ceased. Borings have since proved the seam on the other side of the fault. The faulted portion is only a block which has slidden into the coulee, and mining was carried on in the slumped portion."

"A 10-ton lot of lignite from the Consumers Coal Company's mine was tested at the fuel-testing plant of the Mines Branch, Department of Mines, Ottawa, and it was concluded that this lignite may be pronounced as an excellent fuel for the production of power when utilised in a producer gas power plant. An approximate analysis of the coal is as follows:

Moisture	32.42 per cent.
Volatile combustible matter	28.29 per cent.
Fixed carbon	31.32 per cent.
Ash	7.97 per cent.

"Other outcrops and reports of borings show that the area about the forks of the Lake-of-the-Rivers contains a considerable quantity of lignite."

The location of the coal seams outcropping at the northern end of the Lake-of-the-Rivers make them of special interest in any

scheme for generating electric power at the coal fields. The area was visited by the undersigned in October, 1927, and the following details observed

The William Woodend mine in section 3. township 11, range 28, west of the second meridian and on the west side of the west arm of the lake, is the only development taking place at the present time. The mine was operated during January and February, 1927, and 54 tons of coal were mined. When visited in October, the old adit had caved in and a new adit was partially completed. The seam worked was three feet thick with a small clay parting near the centre. A white, hard clay made a fair roof. This particular seam is too poor for economic mining.

In section 27 on the same side of the lake a caved adit and waste pile that indicated that considerable coal had been mined at some time in the past.

Two other small outcrops were found on this side of the lake, but no exposures were found from which the thickness or the quality of the coal could be determined. To obtain this information, shallow drilling would have to be done. The site of the old workings of the Consumers' Coal Company, already mentioned on the east side of the east arm of the lake, in section 36, township 10, range 28, west of the second meridian, was examined. The old adits have long since caved, but the large piles of waste coal bear evidence of considerable mining activity in the past. Small outcrops and badger diggings indicate a considerable area underlain by coal to the south of the old mine and there appears to be little room to doubt that sufficient coal is available at this point for power purposes.

The seam can be reached by adit from the river bank and lies approximately 35 feet above the level of the lake. An excellent power site is available on a flat bench practically at lake level and can be reached without difficulty from the township road.

Two samples of water were collected and analysed to indicate their suitability for boiler feed water and condensation purposes. The analyses were made in the Department of Chemistry of the University of Saskatchewan, and are as follows

	Water (1), from East arm of Lake			Water (2) from West arm of Lake		
		Grains per gal			Grains per gal	
	p.p.m.	Imperial	U.S.	p.p.m.	Imperial	U.S.
Total Alkalinity (CaC03	969 5	67 86	56 55	859 9	60 19	50 16
Lime (Ca0).	41 2	2.88	2 40	28 5	2 00	1.67
Magnesia (Mg0)	130 0	9 10	7 58	116 0	8 12	6 77
Sulphates (S03)	1390	97 30	81 08	1231	86 17	71 81
Chlorides (C1)	26 1	1 83	1.52	24 1	1 69	1 40
Silica (S102)	3 0	0 21	0 17	4 0	0 28	0 23
Total solids (180 c.).	3932	275 24	229 37	3490	244 30	203 58

The above expressed in hypothetical combinations are as follows:

Calcium bicarbonate (as $CaCO_3$)	73 6	5 15	4 23	60 9	3 56	2 97
Magnesium bicarbonate (as $CaCO_3$)	322 3	22 55	18 79	287 6	20 13	16 78
Magnesium bicarbonate (as $MgCO_3$)	271 5	19 00	15 83	242 3	16 96	14 13
Sodium bicarbonate (as Na_2CO_3)	606 0	42 56	35 47	553 7	38 76	32 30
Sodium sulphate (as Na_2SO_4,	2466	172 62	143 85	2135	149 45	124 54
Sodium chloride (as NaCl)	43 0	3 02	2.52	39 7	2 80	2 33
Total incrustating solids.						
Sum of calcium and magnesium (as $CaCO_3$) and silica .	398 9	27 91	23 24	342 5	23 97	19 98
Total non-incrustating solids	3117 0	218 20	181.84	2728 4	191.01	159 17

The analyses would indicate that the lake water is quite suitable for condensation purposes, and that the total of incrustating solids present is not excessive. The high proportion of sodium sulphate would no doubt be detrimental, causing foaming of the feed water

The quantity of water is ample, as the lake is of fair dimension, being some twenty miles long by one mile in width. The depth of the water adjacent to the coal seams may be somewhat lower in a dry year, but should always be sufficient to meet the requirement of a large steam plant In a dryer year the relative proportions of solids in the water would be higher

As regards transportation, the coal in section 36, township 10, range 28, west of the second meridian, is at present five miles from the railway The proposed extension of the Amulet Candross branch line of the C P R. will undoubtedly pass immediately over the coal lands.

Although it would appear from the confident tone of the various investigators of the Dominion Government that there is available in this area (the north end of the Lake-of-the-Rivers) a sufficient supply of mineable coal of suitable quality to meet the requirements of a large power plant the writer was unable to check the thickness of the seams or their lateral continuity A series of shallow drill holes is the only method of obtaining this information.

Respectfully submitted,

(Sgd.) W. H. Hastings,
Engineer to the Bureau of
Labour and Industries.

I have attached a number of paragraphs copied from other reports and bearing on the coal situation in Saskatchewan. Some statistics on coal production from eight of the largest mines in the province and a list of all the mines with their location and production are also included

The following is an extract from Memoir 89, No. 75 Geological Series, written on Willowbunch Coal Area, by Bruce Rose, 1916, page 67:

"Sample No. 10 is from a seam outside the map-area on the property of the Consumers' Coal Company, near the north end of the Lake-of-the-Rivers. The seam outcrops along the old valley in which the lake lies, in section 28, township 10, range 28, west of second meridian. At the time the property was visited, the seam had been exposed by stripping, and it is now being mined. The seam is approximately 5 feet thick.

On the east side of the same lake in section 36, township 10, range 28, west of the second meridian, the Consumers' Coal Company have carried on mining operations on a 7-foot seam and several hundred tons of the lignite have been mined and used locally. A fault was encountered and mining ceased. Borings have since proved the seam on the other side of the fault. The faulted portion is only a block which has slumped into the coulee and mining was carried on in the slumped portion.

A 10-ton lot of lignite from this mine was tested at the fuel-testing plant of the Mines Branch, Department of Mines, Ottawa, and was pronounced to be an excellent fuel for the production of power, when utilized in a gas-producer plant."

Extract from page 20 of the Report on South Saskatchewan Water Supply Diversion Project.

By H. E. M. Kensit, M.I.E.E.

The Consumers' Coal Company

The nearest developed coal mine to the river is that of the Consumers' Coal Company, situated on the Lake-of-the-Rivers, about 35 miles due south of Moose Jaw (see Plate 38). The head office of this company is in Moose Jaw, and the president is Mr. John E. Chisholm, LL.B.

Distance.—This mine is distant in an air line from Elbow less than 100 miles, as against about 220 miles to the coal fields near Estevan, which would be a large consideration in the cost of transmitting electric power to the river. The distance via Moose Jaw and the Canadian Pacific Railway line to Elbow would be about 115 miles, but this route would give an opportunity to supply light and power to intermediate towns and would thereby reduce the cost of transmitting power to the pumping station.

Quantity. This property was inspected by Mr. D. B. Dowling, B.Sc., of the Geological Survey, Department of Mines, in June, 1912. He said: "There is an eight-foot seam and an estimated quantity of 11,000 tons per acre. * * * it would be a good gas producer as well as fuel for cheap power. * * * it will double the former estimate (18 million tons), of Saskatchewan's

coal supply * * * * With the coal there in such large quantities, the proper thing to do is to put the city (Moose Jaw), power plant right there * * * * Much of the coal waste could be utilised in generating power, giving the city a remarkable advantage for cheap current."

Quality—A shipment of coal was submitted by the company to the Mines Department, Ottawa for a test to its qualities in a gas producer, and a report was made under date of July 12, 1912. The conclusions from this report are that

The fuel burned uniformly without the formation of troublesome clinker

The gas generated was tar-free and heating value satisfactory

The engine valves were found to be exceptionally clean after a run of forty hours

The lignite may be pronounced an excellent fuel for the production of power when utilised in a producer gas plant as it arrives from the mine without further treatment The tendency to disintegrate does not in any way interfere with its operation

The approximate analysis by fast coking was

	Per cent.
Moisture	32 42
Volatile combustible matter	28 29
Fixed carbon	31 32
Ash	7 97
	100 00
Coke.	39 29

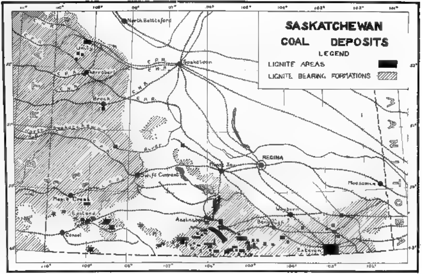
Calorific value of moisture free fuel, 10,000 B T U per pound.
Average effective calorific value of gas per cubic foot, 115 B T U

The report also states that the quantity of coal sent was insufficient to determine the volume of gas generated per ton of fuel, so that this and the thermal efficiency were not determined, but that the indications were that these would have been satisfactory

In a report to the company (mainly concerning their clay deposits), by Dr G A. Charlton Provincial Analyst, Regina, dated October 22, 1912, it is stated that this lignite in appearance and texture closely resembles the coal now being mined in the vicinity of Edmonton.

COAL PRODUCTION IN SASKATCHEWAN, CALENDAR YEAR 1926

File	Name	Address		Tonnage	Months working
2002	G. Parkinson	Estevan	11-2-8-2	3,889	12
4	T. D. Munto	Estevan	14-2-8-2	1,849	7
5	Hamilton & Hazzard	Bienfait	19-2-6-2	79,290	12
6	Western Dominion Collieries	Taylorton	2-2-6-2	86,235	12
7	A. D. Ross	Roche Percee	25-1-7-2	1,049	9
8	Man. and Sask. Collieries	Bienfait	10-2-6-2	86,940	12
9	H. Nicholson	Estevan	16-2-3-8-2	160	1
11	J. G. Peterson	Shand	16-4-2-7-2	21,736	12
12	Big Chunk Mine, Bastien	Estevan	5-10-2-8-2	131	6
13	Bernard Tangedal	Gladmar	8-3-19-2	1,210	6
15	Neale Anderson No. 1	Estevan	29-1-8-2	1,214	9
16	A. Hewer	Readlyn	17-3-21-2	200	12
21	L. Bourguin	Estevan	12-2-8-2	3,900	3
22	Souris Valley (E. Seddall)	Roche Percee	24-1-7-2	2,455	9
26	Jas. Salaba	Willow Bunch	18-5-27-2	749	4
27	R. Campion	Readlyn	28-7-29-2	477	5
28	Lark Mine (E. Scott)	Bengough	3-5-22-2	291	4
30	Crescent Collieries Ltd.	Estevan	22-2-7-2	24,681	10
34	Goose Neck Mine, W. Johnson	Hart	32-3-26-2	143	7
35	Eastern Collieries Ltd.	Bienfait	34-2-7-2	22,225	12
42	L. M. Anderson	Roche Percee	6-1-6-2	36	3
43	Leoppky Bros.	Shaunavon	30-7-18-3	87	4
45	W. H. Trueaven	Wauseka	2-4-23-2	264	7
47	W. J. Johnson, J. Mather	Estevan	15-21-2-8-2	637	3
50	Sasa Coulee (D. Campbell)	Roche Percee	25-1-7-2	181	1
53	W. H. Rollason	Estevan	14-1-2-8-2	2,644	11
56	Badger Mines (H. Banks)	Pinto	26-1-6-2	541	6
58	M. Sorensen	Big Beaver	26-1-24-2	648	6
60	E. Hibstrom	Estevan	10-1-2-8-2	164	11
61	Paul Underfinger	Estevan	7-2-7-2	1,515	12
064	Chas. MacFarland	Eddystone	11-2-26-2	941	6
	Neale Anderson No. 2	Estevan	29-1-8-2	82	7
	T. J. Ferris	Eastend	1-7-22-3	143	6
	Big Lump Coal Co.	Estevan	13-2-8-2	33,765	12
	Lignite Coal Co., Ltd.	Taylorton	35-1-6-2	10,817	6
	Frank Underfinger	Estevan	30-7-2-7-2	68	1
	Smith & Needles	Eastend	35-6-22-3	108	5
	Henkin Slater	Gladmar	11-3-19-2	680	7
	A. Nee	Estevan	21-2-8-2	2,447	12
	Chas. Spocha	Verwood	16-6-2-7-2	932	9
	D. E. Slater	Roanmine	16-3-21-2	636	9
	Reinhold Unteaner	Bengough	24-4-23-2	360	3
	W. Seargent	Shaunavon	36-7-19-3	226	7
	Red Devil Mine (T. McLean)	Estevan	9-2-8-2	109	3
	Coppey Mine (Woodend)	Ardill	3-11-8-2	84	2
	Johnson & Scott	Hart	29-3-26-2	225	5
	W. S. Blain	Shaunavon	14-19-7-16-3	187	5
	Beaver Dam (A. Jahn)	Roche Percee	14-1-7-2	175	2
	Drechanger, J. G.	Willow Bunch	1-6-28-2	315	3
	Annie Salaba	Willow Bunch	14-5-28-2	426	3
	J. Olchanowski	Estevan	13-2-7-2	2,073	12
	Jas. Parkinson	Estevan	11-1-2-8-2	1,060	12
	W. A. Grabarger	Estevan	9-2-8-2	1,016	12
	International Clay Products	Estevan	9-14-2-8-2	3,148	
	M. Muirhead	Estevan	22-2-8-2	830	
			Total	451,077 tons.	


SASKATCHEWAN
COAL DEPOSITS
LEGEND
LIGNITE AREAS
LIGNITE BEARING FORMATIONS
North Battleford
Saskatoon
Unity
Kerrobert
Brock
C.P.R.
C.N.R.
REGINA
Moose Jaw
Swift Current
Maple Creek
Eastend
Consul
Assiniboia
Bengough
Weyburn
Estevan
Moosomin
North Saskatchewan River
MANITOBA
ALBERTA

Saskatchewan Coal Production (By Months) of Eight of the Largest Mines, 1926-27

	July	Aug	Sept	Oct.	Nov	Dec.	Jan	Feb.	March	April	May	June
Bienfait Mines	3,010	2,835	6,189	8,704	16,216	12,198	9,210	8,753	6,224	4,167	4,015	3,021
Western Dominion Collieries	3,613	3,481	7,506	11 282	20,352	15,631	11,281	12,358	6,338	4,887	3,438	3,449
Manitoba and Sask Mines	3,157	3,739	6,777	11,822	17,153	17,071	12,951	10,536	8,611	5,578	3,528	3,694
Shand Collieries	1,479	1,128	2,041	3,675	4,975	4,506	3,987	2,506	1,478	1,063	1,238	1 274
Crescent Collieries		712	538	1,588	2,062	2,620	2 954	2,845	3,100	4,343	2,089	1,631
Eastern Collieries	1,424	1,730	2,350	3,357	6,570	4,971	3,270	2,260	2,970	2,079	1,545	993
Big Lump Coal Co	165	249	1,488	4,692	6,393	7,564	4,378	4,020	2,006	1,166	544	
L. Bourquin				1,100	1,500	1,300	1,100	1,100	250	180	80	120

APPENDIX No. 8

Rural Electrification, By W. H. Hastings

The following brief review shows the world wide interest being taken in the question of the application of electricity to agriculture.

England. Although England is not as far advanced in the matter of rural electrification as some other European countries, the recent report of a committee on electricity in agriculture made to the Institution of Electrical Engineers indicates that the application of electricity to agriculture is being seriously considered in England.

The committee believe that farmers will find electricity profitable and will use it widely if they can get it for 16 cents per kilowatt hour for lighting, 4 cents for heating and cooking and 8 cents for power, with an electric ploughing rate of from 2 to 4 cents per kilowatt hour.

Germany. In Bavaria, Germany, great progress has been made during the last ten years in the electrification of the rural districts. The total population of Bavaria, including the Palatinate, is about 7,150,000, of whom 30 to 40 per cent are engaged in agriculture.

In 1921, approximately half of the rural homes had electric light and one-ninth had power. Within five years it seems probable that practically every farm will be included in the electrified district. This progress has been made possible by the combined efforts of government and privately owned central stations, farmers' co-operatives and the farmer himself.

As elsewhere the distribution has been most effectively accomplished by farmers' co-operatives, which construct and operate many of the rural local distribution systems. These co-operatives purchase the energy from the central stations at wholesale rates and pro-rate the total cost among their members in accordance with their consumption.

Besides the general uses to which electricity is put on the farms in other countries, in Bavaria current is used to dry hay and grain, and to some extent to operate electrically driven ploughs.

France. The population of France is nearly 37 millions or about 173 per square mile. The occupation of the people is essentially agriculture and about one-half of the population can be classed as rural. The farms are small, a large proportion being less than 12½ acres in size. The chief crops are grains, beets, potatoes, grapes and hay.

Up to the present time progress in rural electrification has been largely confined to the north of France. The electrified farms are those of comparatively large size, 100 acres or more.

The uses to which electricity has been put on French farms have so far been mainly limited to lighting and to the operation

of presses, dairy machinery and pumps. It has been used to some extent for threshing. Electric ploughing has been successful on some of the large farms.

In 1923 an Act was passed authorising government loans at low interest rates to communes and co-operative societies to enable them to establish rural electric service. There is every indication that rural electrification will be rapidly developed in France within the next few years.

Italy—Considerable progress has been made in electrifying the farms of Italy. Northern Italy is already a net-work of transmission lines, and electricity is used extensively for pumping, ploughing, harrowing, threshing, cutting, grinding and many other farm operations. Many co-operative distribution societies are functioning and the government has offered a small subsidy to central stations in proportion to the weight of the copper used in transmission lines.

Denmark. Prior to 1918, few farms in Denmark had electricity, but since that time rural electrification has been so rapidly extended that about one-half of all the farms now have electric service.

Large central stations operated by steam or Diesel engines are the rule in Denmark. There are also two large and a few small hydro stations.

Sweden.—Ten years ago rural electrification was practically unknown in Sweden. The large consumers in the cities were the controlling factors in the industry. During the war Sweden was cut off from its main supply of oil and coal and was forced to seek electric power. Today, 40 per cent. of the 9½ million acres of tilled land has access to electric power. About one-fifth of this electrified farm land is in the north and four-fifths in the richer central and southern portions of the country.

This rapid development has come about through many different agencies, the most important of which are the state owned electric systems in central Sweden, the larger private power companies, and the farmers' co-operative societies.

The Swedish Government has been very energetic in the matter of electric development. More than one-third of the electrified area is supplied from the three government stations in central Sweden. In 1924 the government appointed a royal committee to investigate the electrical rates charged by government and private rural distribution companies with a view to making recommendations of rate changes which would lead to a wider use of electricity. As a result of the investigation, a new rate schedule was set up which it is believed will meet the power requirements and economic possibilities of the rural distribution organisations and will at the same time encourage a much greater use of electrical energy than would be possible with higher rates.

United States. The importance and desirability of rural electrification has been recognised nationally in the United States

Besides a National Committee on the Relation of Electricity to Agriculture, twenty-two separate state committees have been organised and are carrying on research and investigational work in the field.

From the first it was realised that the national committee should be thoroughly representative if best results were to be obtained The personnel was made to include representatives from the Departments of Agriculture, Commerce and Interior the Farm Bureau Federation, the American Society of Agricultural Engineers Manufacturers of Individual Plants, the National Electric Light Association, the National Association of Farm Equipment Manufacturers the National Federation of Women's Clubs and the American Home Economics Association

Through the National and State Committees, intensive and painstaking experiments are conducted covering the application of electric service to irrigation, dehydration, poultry raising, general farm water supply, refrigeration, electric cooking, water heating, feed grinding, wood sawing hay hoisting threshing and elevating grain cutting ensilage, drying of farm products, fire prevention, general farm lighting and the use of all kinds of standard household electric appliances.

Of the six and one-half million farms in the United States, only a small fraction are receiving central station electric service at the present time and only 4 per cent of the power used on American farms is electric

Many problems still confront the broad application of electricity to American agriculture Encouraging progress towards their solution is being made A favorable public attitude towards the enterprise has been secured by enlisting aid from all important sources, including government departments, equipment manufacturers, the farmers themselves and the light and power companies.

Preliminary surveys have been made by many of the state committees and a great deal of experimental work has been started. Some of the minor problems have been solved and the ground work laid for the working out of more complicated problems such as the development and standardisation of lines and equipment and the development of a standard practice and nomenclature

Ontario.—Some early attempts at electrification of farming districts in Ontario took place before 1913 Prior to 1920 comparatively little progress was noticed, but since that time great strides have been made.

About 1911 legislation provided for rural service largely through extensions of feeders from the municipalities at corresponding rates and under similar conditions as prevailed in the municipalities. This method was found unsatisfactory on account of the

apparent injustice which worked to the disadvantage of the man on the back lines of the township.

In 1920 new legislation was passed under which authority was given to the commission to serve rural customers directly and to form rural power districts. Within these districts rural electric service is given at the same rate for the same class of service.

In 1921, to aid rural service still further, legislation was passed whereby the government gave a bonus of 50 per cent. of the cost of rural primary distribution lines, and in 1924 authorised a similar bonus for rural secondary lines. Thus the government of Ontario now pays 50 per cent of the cost of all construction of rural lines, thereby reducing the interest and sinking fund charges on the capital investments one-half.

Rates for rural customers are based upon service "at cost" and are made up on a secondary basis of classes of service and a sub-division of cost basis.

The rural power districts are located mainly in the richer, more closely populated farm centres. A comparatively few farm lines are in operation in the newer districts where large farms are found. A large majority of the rural lines serve hamlets or industrial users in addition to the farm consumers.

In nearly all districts the rural load has grown rapidly. Some rural districts have not grown and loads have remained stationary or decreased, but as a whole rural service has been an enterprise that has paid its way with the aid of the government and has meant a great deal to the building up of the territory.

The following table indicates the progress in rural construction in Ontario from 1922 to 1926:

Year	No. of rural power districts operating	No. of consumers	Miles of primary line	Total capital invested
1922	30	1,511	335	801,006
1923	52	4,167	605	1,328,261
1924	82	9,961	909	1,967,548
1925	95	12,895	1,288	2,658,515
1926	107	17,065	1,953	4,005,163

According to Frederick A. Gaby, Chief Engineer, Hydro Electric Power Commission, Ontario: "The extensions being made in the main transmission and distribution lines of the municipally owned hydro-electric undertakings are constantly opening up new rural territory, and present indications are such as to promise for the future an unprecedented extension of rural electric services in Ontario."

Manitoba and Alberta. In both Manitoba and Alberta, beginnings have been made in the distribution of electricity in rural districts. In Manitoba the work is carried on by the Manitoba Power Commission, which has been in operation since 1919. The

commission was appointed by the Manitoba Legislature to undertake the transmission and distribution of electrical energy from Winnipeg throughout the province, and to build isolated plants in those localities to which it would not be economical to extend the transmission system

Although operation of the lines built by the Commission was not very successful in the early stages, the system is now being operated at a small profit The potentialities of the utility are becoming more widely known and more appreciated by the people of Manitoba. Many applications are received monthly by the Commission for estimates of the cost of service in different communities, and a more aggressive and comprehensive plan of extension is expected for the future

In Alberta, the Calgary Power Company is branching out into the field of urban and rural electric distribution In 1927 this company built 150 miles of 66,000 volt transmission line 265 miles of 13,200 volt line and 60 miles of farm service line

It is too early to predict what success these new extensions will meet with, but from the start the demand for service on the rural lines has been greater than the ability of the power company to make connections.

Summary of the World's Experience with Rural Electrification

From the foregoing brief summary of what is being done in other countries, it is evident that rural electrification is being recognised nationally as a question of paramount importance in many of the leading countries of the world.

Substantial progress has been made in bringing electricity to the farm, notably in Germany, Denmark Sweden, Ontario and some portions of the United States.

Greatest progress appears to have been made where the rural distribution systems are financed by the distributing company or co-operative groups and not by the individual consumer Where the company is unwilling to finance the system, the way should be left open for the formation of a farmers' co-operative group who can purchase power wholesale from the power company and distribute it among the members.

The Problem of Rural Electrification as Affecting Saskatchewan

In Saskatchewan the problems encountered in proposing a general scheme of rural electrification are considerably different from those obtaining elsewhere, and certain important factors are seen to be peculiar to this province alone

Saskatchewan is a very young province Her development has been rapid and one-sided Agriculture has been emphasised almost to the exclusion of other industries. New industries are growing up but have not yet reached the point where they are large power

users. Her cities are as yet comparatively few and these are small. It is evident that large power transmission lines running through the province will not be a factor in bringing central stations within reach of rural districts until the province has had time to experience considerably greater growth. Some of the larger towns and villages may be linked by power lines from small central stations, and each of these small towns on such a line will provide starting points from which rural extensions may be run.

Saskatchewan is very sparsely settled, having a density of population of six persons per square mile as compared with ten for Manitoba and twenty-eight for Ontario. In Saskatchewan now and for some time to come not more than one subscriber per mile could be expected, whereas it is generally conceded that an average of three customers per mile is the minimum which can be given service with a fair chance of profit. This is the minimum adopted by the Ontario Hydro Electric Commission and in Manitoba two customers per mile are required before a rural extension is considered.

General Rural Electrification Problems

(a) Returns on capital are small compared with urban distribution.

(b) Capital investment per customer is high.

(c) The load factor is low and the demand is irregular. Lighting is often the chief electrical use.

(d) Low density of population and small consumption.

(e) Rate structures are usually complex and not easily understood by the consumer.

(f) Cost of service and equipment is high.

(g) While many new uses have been found for electricity on the farm its application to those machines such as ploughs and threshing machines which use a large amount of power has not been developed to any considerable extent.

The factor of time will be all in favor of the ultimate success of rural electrification in Saskatchewan. The population is rapidly increasing, new industries are being built up and the farmers themselves are becoming more firmly established in the agricultural occupations. Mixed farming is on the increase. With it will come new types of farm work to which electricity may be applied.

Many of the problems which at present confront the application of electricity to agriculture may be overcome by

(a) The education of both the producer and consumer to the problems of the other.

(b) Standardisation of lines and equipment.

(c) Uniformity in rate schedules.

(d) Low rates and an educational campaign to encourage a more wholesale use of electricity on the farm, especially for purposes other than illumination.

In seeking to conjecture what the future wil bring in the way of rural electric development in Saskatchewan, several questions present themselves.

(1) As to whether or not

(a) The development of transmission of power in Canada or elsewhere has tended to the electrification of the farms which are adjacent to the transmission lines and which can be served thereby

The progress in rural electrification described elsewhere in these pages in Germany, Denmark, Sweden and other countries may be claimed as a direct result of the large scale transmission of power in those countries.

J W Purcell and A A Lang, Assistant Engineers, Hydro-Electric Power Commission of Ontario, may be quoted as follows "The construction of high voltage lines through the country from the generating stations to high tension stations, and from them to towns, cities and villages, has probably been the main cause of originating a desire in the minds of farmers and residents in rural districts for electric service."

"It should be appreciated that without the transmission networks that have been constructed to serve the cities and towns of Ontario any extensive rural electrification would be impossible Generally speaking the small loads distributed to the rural power districts would not by themselves justify the construction of transmission lines to bring electrical power from a distant source"

H B Walker in charge of Agricultural Engineering, Kansas State Agricultural College, in discussing the present status of rural electrification in Kansas, says Rural electrification in Kansas as it exists today is largely the result of the demand of the farmer upon central stations for rural extensions."

And again, Robert F Pack, First Vice-President, National Electric Light Association, in discussing farm electrification in the United States, points out that the urge towards receiving service by the farmer commenced when he saw transmission lines passing through the country He quite naturally asked for service, and the companies showed a willingness to supply the service

It must not be inferred from the foregoing that wherever a high power line passes through a rural community the residents can be connected directly to it The reason for this is that electricity under the high voltage used in long distance transmission must be stepped down through transformers to a low voltage before it can be used for light and power purposes. This transforming of voltage is a costly process and is only warranted where a fairly large load is to be taken from the main transmission line In general, rural extensions must originate from sub-stations at towns or hamlets where connections to the primary lines have already been made.

There are few, if any, countries where the development of power transmission on a large scale has not been followed at least to some degree by the electrification of the adjacent rural districts.

(b) Whether or not the use of electricity on the farms has materially increased since the distribution of power in other provinces or elsewhere.

With this question of use lies one of the most important problems of rural electrification. It is only by increasing the consumption of electricity by applying it to other uses than illumination that the electrification of the farm can be made to show a profit or even be self-supporting.

It costs about five times as much to serve a rural customer as it does to serve a city customer. If the farmer is going to be as profitable a customer to the producer and receive energy at a price comparable with the city user, he should use approximately five times as much electricity as the latter. It would, however, be folly for the farmer to consume large quantities of current simply to obtain current at a low rate. It must be shown that he can use energy in quantity and at the same time profitably to his business.

The following examples are given in support of the statement that the general experience has been that the farm load grows from the time the service connection is made.

In Ontario in nearly all districts the rural load has grown rapidly. In the Niagara system, for example, which has the largest number of rural districts, there were fifty-one districts as of October 31, 1924, of which seventeen were added during 1924. In thirty-six of these districts the load increased during the year. The average increase was 49.1 per cent, for those districts in operation for the full year.

E. C. Easter of the Alabama Polytechnic Institute may be quoted on the subject of growth of farm loads as follows: "No return can be realised on the money invested for the first few years, but after the farmer is on the line he gradually builds up his load until it is profitable. As an example of this, there is a line in Alabama that has been in service since 1920. At the beginning this line served one cotton gin and ten farmers. With practically no additions to the line the load increased from 18,000 kw. hr. in 1920 to 60,000 kw. hr. in 1925, or over 233 per cent."

Recognising the importance of encouraging a greater use of electricity by farmers on rural lines several of the state committees on the Relations of Electricity to Agriculture constructed experimental lines and carried on educational programs on the application of electricity to farm operations. Among other important discoveries made on these experimental lines it was found that the load could be materially increased by educating the farmer in the use of new electrical equipment and pointing out the various ways of applying electricity to farm work. For example, one such test line at Renner, South Dakota, where the patrons bought their own equipment and without any particular encouragement from those in charge of the line, salesmen solicited patrons for equipment with the result that the average consumption of the 17 farms on the line increased from 41.12 K.W.H. in January to 117.47 K.W.H. in December of the same year.

In some cases where investigation showed that rural loads were stationary, the cause was attributed to the inability of the farmer to make the necessary initial expenditure for equipment, or the existence of a high energy rate which discouraged the use of large amounts of current. In these cases it was found that the farmer was only using current for illumination and consequently was considered a poor customer

(c) Whether or not the transmission of power in this province would create a material demand from the farming communities for electrical energy

The transmission of power elsewhere has resulted in a demand for service from the farming communities adjacent to the transmission lines. It would appear reasonable to assume that it would do so in Saskatchewan

The question of convenience and desirability for lighting and small domestic and household purposes cannot be doubted. Every farmer wants service for these purposes if he can afford it

The situation with regard to the larger power uses on the farm is somewhat different. Grain farming in which most of the power used is mobile, does not readily lend itself to the application of electric power. Diversified farming in general offers more opportunities for the use of electric energy than straight grain production, while dairying, chicken farming, etc, can make up an especially attractive electrical load

However, even on farms carrying on large scale grain operations, there are a great many uses which require sufficient power to warrant the installation of a fair-sized motor

Electric threshing and ploughing have been tried with fair success in Germany and elsewhere in Europe, but it would appear that on Saskatchewan farms the gasoline motor will be the more efficient form of power for this class of work for some time to come

(2) As to whether it would be desirable to utilise existing pole lines in the province for the transmission of power in rural districts and sparsely settled localities.

The question of the joint use of pole lines, as telephone and power lines, leaves considerable room for argument and there are champions of both sides of the question

Joint use is practiced to some extent in the United States, particularly in Vermont and Virginia, but there are those who do not look with favour on such practice G C Neff of the Wisconsin Power and Light Company, and Chairman of the Rural Electric Service Committee N.E.L.A., may be quoted on this question as follows. 'All lines should be built in accordance with the best standards and of the best materials It is necessary that the lines be built in the best manner to make them safe to insure continuity of service to the consumer, and to keep the maintenance and operating cost of the line low It has been found that it is cheaper to build a first-class line than it is to build a cheap, low-grade line. The

maintenance of a cheap, low-grade line and the operating costs are much higher than those of a high-grade line. This more than offsets the additional interest which must be paid on the high-grade line. All reputable electric companies follow approved standards in the construction of electric lines."

Speaking on the same subject, W. H. Onken, Jr., Editor, *Electrical World*, says, "Former ideas on rendering electric service to farms are fast going out of date. Development of extensive, profitable, individual utilisation of electricity—not crimping in line construction costs—is the solution. If electric service is to be developed on an income producing basis for the farmer, power for milking, incubation, operating chore motors, etc., cannot be interrupted or curtailed by inadequate line construction."

In Ontario, joint use of poles with the telephone companies is practiced with a limitation of 5,000 volts, and experience has shown that liability in the event of accidents is the most troublesome problem to be worked out in connection with joint use operation.

An argument in favor of using existing telephone lines, at least for pioneer development, to carry low voltage lines has been worked out by S. R. Parker, Provincial Government Telephone Department, who points out that in our provincial telephone lines we have a distributing system already available and asks "Why not use it?" The lines generally are of high class construction, and Mr. Parker has worked out clearances between wires and between wires and ground which he claims reduces possibility of interference to a minimum and at the same time provide adequate safety factors. He also suggests that some of these lines will soon have to be replaced and that the new lines should be designed with a view to joint use of telephone and rural power distribution lines.

There would appear to be no reasonable objection to such joint uses, to some degree, especially in the case of new lines which could be properly designed to meet the requirements of both utilities.

Conclusion

In concluding this brief discussion of rural electrification and its application to Saskatchewan farms, a few generalisations may not be out of place.

1. Electric service for agriculture is a worthy, important and big undertaking.

2. Owing to a low density of population, advancement of the project in Saskatchewan will be by the extension of the distributing systems of cities, towns, villages and hamlets to reach such farm and rural users as see the advantage of taking electric service.

3. Rural electric lines should be built only to groups of farm customers who will agree to use a sufficient amount of energy in a manner that will enable them to profit while paying

to the utility which serves them a rate sufficient to pay the cost of the service.

4. Rural extensions and poor farming conditions will not mix.

5. The experience of rural electrification elsewhere should be studied and their mistakes avoided.

6. To insure sound developments, its growth requires intelligent direction

APPENDIX No. 9

Economics of Rural Electrification

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General

The problem of rural electrification resolves itself principally into a question of economics. On account of the distance between farmer consumers, the capital invested per consumer in transmission and distribution lines is relatively high as compared with the corresponding capital expended in towns and cities. The number of consumers per mile of distribution lines varies from about 20 consumers per mile in villages and small towns to from 50 to 100 consumers per mile in the larger towns and cities.

The average number of consumers per mile of distribution line in the city of Regina, for example, is about 96, whereas the average number of consumers on existing lines in farming communities is seldom more than 10, and frequently averages not more than three or four consumers per mile. In Saskatchewan, where the farms are large, there are few rural districts which would give an average of more than three consumers per mile, and in many districts the average number of consumers per mile would be less than this.

In order to keep the average fixed charges per K.W.H. or current supplied to the consumer within a reasonable amount, it is evident that each farm consumer must take considerably more current than the average city consumer, and this can only be brought about by developing the use of electric motors on farms as much as possible, since it is obvious that if the farmer uses current for lighting and domestic appliances only, his total consumption will not exceed that of the average city consumer.

The effect of the amount of current consumption on the average cost of supplying current may be illustrated as follows.

Assuming a rural power line to cost about $1,200.00 per mile, which is an average figure, and that there are three consumers per mile, the capital investment in transmission line will average $400 per consumer. If the cost of generating the current be taken at four cents per K.W.H., the average cost of current to typical farm consumers will be as follows:

	Farm using 100 K.W.H. per year	Farm using 400 K.W.H. per year	Farm using 1500 K.W.H. per year
Interest on capital outlay at 5%	$20.00	$20.00	$20.00
Depreciation, repairs and maintenance 10%	40.00	40.00	40.00
Office expenses, meter reading, etc.	5.00	5.00	5.00
Electrical losses in line transformers, etc., at ?c. per K.W.H.	10.20	12.40	24.00
Current used at 4c. per K.W.H.	4.00	16.00	60.00
Total cost per annum	$79.20	$93.40	$149.00
Average cost per month	6.60	7.78	12.41
Average cost of current per K.W.H. consumed, cents	79.2c	23.3c	9.9c

It will be noted that the average cost per K W H decreases rapidly as the annual consumption increases

In rural electric service the cost of generating the current is thus only a small part of the total cost of the service and if the cost of generation were entirely eliminated the cost of rural service, as now used, would not be very greatly reduced

The more extensive use of electric current for power purposes on farms may be encouraged by fixing the service charge sufficiently high to cover fixed charges on capital with a correspondingly low energy charge per K W H actually consumed

It is often difficult to get the rural consumer to see the necessity of the high service charge required to cover the fixed charges on the transmission line and the difficulty is sometimes met by encouraging farm consumers to construct and maintain the transmission line at their own expense the power company only supplying the energy In other cases the farmers construct the line and hand it over to the power supply company which undertakes the responsibility of maintaining it or alternatively the farmers to finance the line, which is constructed by the power company This latter arrangement is calculated to ensure a good type of construction so as to reduce line losses and cost of maintenance as much as possible It appears however, on the whole to have been found preferable for the power supply company to both finance construct and maintain the line, recouping themselves for the cost either by an adequate service charge or alternatively by a comparatively high initial charge per K W H for the first block of current consumed with a correspondingly lower service charge

Transmission and Service Voltage.

The operating voltage of long distance transmission lines between cities and large hydro-electric generating stations is usually 66,000 or 110 000 volts Branch lines may be taken from the main trunk to smaller towns and villages at 40,000 or 22,000 volts These voltages are too high to permit the trunk and branch lines to be economically tapped for the supply of individual consumers along the route as the cost of sub-stations and transformers relative to the amount of current taken off would be excessive Maximum voltage of transmission lines from which farm and village loads may be economically tapped appears to be 11 000 volts with star connection

Star connection presents some advantages over Delta connection in this respect, since the voltage in each phase instead of being equal to the line voltage, as in Delta connected lines, is equal to the line voltage divided by 1 732 This enables individual farm consumers to be served with single phase current by means of 6,600 volts transformers at a cost not greatly in excess of transformers of the usual 2,200 volt type

Current may be economically transmitted at 11,000 volts over a distance of 30 miles or more Rural lines, however are more

usually operated at 4,000 or 2,200 volts. This enables the lines to be constructed at the minimum cost for the transmission line and service connections.

The distance of economic transmission is, however, somewhat limited, and as sub-stations, on account of their cost, can only be installed in towns and villages where the consumption is sufficient to justify the cost of installing a sub-station, rural service is often limited to a comparatively short radius from towns and villages. There are, however, a number of cases of rural transmission at a comparatively low voltage over considerable distance where the total demand on the line is not very great.

The service to individual consumers is usually single phase, except where the demand for current for use in motors is sufficient to justify installing a three-phase line.

Cost of Rural Transmission Lines

The cost per mile of rural primary lines varies very considerably according to the type and standard of construction.

The cost of rural lines constructed by the Ontario Hydro-Electric Power Commission varies from about $840 per mile to $4 350 per mile, the average cost per mile of primary rural transmission line over the whole system being about $1,332 per mile.

The cost of one mile of a typical rural wood pole line with three-phase circuit installed complete, including supervision and overhead charges, is given in a report by the Chief Engineer of the Hydro-Electric Power Commission of Ontario at $1,308.38 per mile. The cost of one mile of a typical rural wood pole line with single-phase circuit installed complete including supervision and overhead charges, is given at $1,062.82. The above estimates are for 4 000 or 2 300 volt circuits with 30-ft. poles set at 160 feet maximum spacing, conductors No. 6 B. & S. Gauge bare wire. Where the primary circuit is three-phase, a neutral wire, usually ¼-inch steel stranded and galvanised, is used.

For single-phase circuits, underground cables have been used to a considerable extent. The standard underground cable is usually of No. 6 B. & S. Gauge stranded copper with rubber insulation and lead sheathing.

The cost of a single-phase circuit with underground cable, including laying and supervision, is given at $799.26 per mile. At each point where service is taken off, a wood pole is installed on which the cable is terminated at an additional average cost of $47.21 for each service.

Underground cable is only used for single-phase lines, as it has been found cheaper to use overhead transmission for three-phase lines.

It may be noted that rural power lines have been constructed at much lower cost than the above. A 2,200 volt, three-phase

wood pole line, numbers 6 and 8 copper conductors, built in Wisconsin in 1921, cost $15,346.34, not including transformers and service connections. The length of the line is 24 miles, and the average cost was thus approximately $640 per mile. A 2,200 volt wood pole line single phase, No. 8 copper conductors 5½ miles long, built the same year, cost $600 per mile. A similar single-phase line 3¾ miles long built in 1918 cost only $346 per mile. It is considered good practice, however, to build lines of a fairly good standard of construction in order to reduce the cost of maintenance and operation.

The estimated cost of building three-phase rural transmission lines of a fairly good standard of construction for 2,200 to 4,000 volt transmission in Saskatchewan, is as follows

Size of Conductors	Dollars per mile
No. 1/0	$1,550
No. 2	1,500
No. 3	1,400
No. 4	1,250
No. 6	1,120

The corresponding estimated cost of single-phase transmission lines is about $750 per mile for No. 6 conductors and $600 per mile for No. 8 conductors. The usual size of conductors used for three-phase and single-phase rural transmission lines is No. 6.

The cost of service transformers, including material and labour of installing, may be taken approximately as follows

Size of Transformer	Cost Installed
1½ K.W.	$ 85
3 K.W.	100
5 K.W.	125
7½ K.W.	160
10 K.W.	185

Single-phase meters cost about $10 each. A 100-ft service drop including installing meter would cost about $20.

Half a mile of secondary service line 15 to 20 K.W. capacity costs complete from $1 000 to $1,500.

From the above data the cost of service for any number of connections per mile may readily be computed.

Conductors of iron wire are used for rural lines in some cases where the amount of electricity transmitted is relatively small, and the distance is not too great, or where the possibility of a greatly increased load in the future scarcely justifies the increased cost of copper conductors. With No. 8 galvanised iron telegraph wire, with 18-inch spacing, three-wire single-phase at 6,600 volts about 15 K.W. can be transmitted a distance of 20 miles with approximately 10 per cent. drop. The capacity of a two-wire single-phase line with 10 per cent. drop over an equal distance would be about 3¾ K.W.

Transmission Line Losses

Transmission and distribution line losses in rural power lines are usually very heavy as compared with distribution losses in towns and cities. The latter may average from 10 to 25 per cent. of the total power input. In Regina the distribution loss is said to

be about 8 per cent. This is a very small amount, and 15 to 20 per cent of the total input would probably represent a fair average for the larger towns. The line losses in rural lines on the other hand amount not infrequently to more than the total amount of current supplied to consumers.

The average line loss in 24 rural power lines in Wisconsin over a period of twelve months was approximately 46.3 per cent of the total electrical input. On the Berwick transmission line, Kansas, the percentage of input lost in transmission and distribution was approximately 55.6 per cent in 1921, 55 per cent in 1922, 53.7 per cent in 1923 and 51.4 per cent in 1924. The input was approximately 25,900 K.W.H. in 1921 and increased to 35,000 K.W.H. in 1924—the corresponding output being 11,500 K.W.H. in 1921 and about 17,000 K.W.H. in 1924—and it is interesting to note the reduction in transmission and distribution losses with the larger output. This line is about 30 miles long and serves 78 consumers, 69 of which are farmers. Transmission is at 6,600 volts single-phase.

The distribution loss on a rural line in Ohio, with about 60 meter connections and 30 service transformers is reported at about 40 per cent of the input. The transmission line loss is principally due to the core losses in the transformers. The loss due to the resistance of the transformer windings may amount to a considerable percentage of the current (say 10 per cent), but these losses exist only when current is being actually used, and are proportionate to the amount of current used by the consumer (except for the loss due to the small current in the primary windings when the transformer is carrying no load), but the core (iron) losses are going on continuously, since the core of the transformer is being continually magnetized as long as any voltage is being impressed on the primary side. Where continuous service is given, the core losses will average from 220 K.W.H. per year for a 1½ K.V.A. transformer to about 875 K.W.H. per year for a 10 K.V.A. transformer. As the average farm connection may use only from about 240 K.W.H. to 1,000 K.W.H. per annum, the relative magnitude of the transformer losses in proportion to the line input is readily apparent.

A method of reducing the transformer losses by means of an automatic cut-out has been suggested, but I am not aware that this device has been tried out.

It may be noted that in rural districts a separate transformer is required for nearly every consumer, whereas, in towns and villages one transformer may serve from 15 to 20 consumers. The proportionate transformer loss per consumer is, therefore, much higher on rural lines than in towns and cities.

Electric Current Consumption on Farms

The current consumption on farms varies within wide limits, and is usually capable of considerable development, if fostered by educating rural consumers as to the advantage derived from using electrical power in farm operations and domestic appliances.

Where current is used for lighting the farmer's house, barns and yard alone, the average consumption will not usually be more than 200 K W H per year, and may be considerably less. On the other hand, by educating the farmer to the extensive use of electric motors the consumption may be increased to many times this amount.

On the Redwing Rural Line, Minnesota, the average current consumption per farmer has been developed to more than 3,000 K W H per annum, an increase of 42 per cent having been developed in one year. The maximum consumption on this line per farmer ranges from a minimum of about 1,840 K W H per annum to a maximum of about 4,000 K W H. per annum.

One dairy farm in Kansas uses about 150,000 K W H per annum.

The consumption per farm in a new district in Ontario, where service has been given for about four years, averages about 672 K W H per annum. In another district where service has been given for twelve years, the average consumption per farm is 1,224 K W H per annum. In six typical farms in Ontario the average consumption for lighting and domestic appliances is given at 357 K W H per annum. Where a 5-H P motor is in use, a typical average consumption per farm for lighting and domestic appliances would be about 650 K W H per annum.

In Kansas, in 46 typical live stock farms, the average consumption per farm was 698 K W H per annum. In 36 farms devoted principally to field crops the average consumption was 739 K W H per annum, and in 19 dairy farms the average consumption was 1,029 K W H per annum.

On the Berwick Rural Transmission Line, Kansas, the average consumption of 68 farms was 240 K W H per farm per annum.

The average consumption of 17 farms on the Renner Line, South Dakota, in 1924, was 785 K.W H per consumer per annum.

In Virginia in 1925, the average consumption of 133 general farms was 389 K W H per farm per year. For 41 live stock farms, the average consumption was 543 K W H per farm per year, and for 105 dairy farms the average consumption was 977 K W H per year. The current consumption on existing rural lines is no doubt capable of much greater development.

A committee of the Giant Power Survey Board of Pennsylvania, after investigations in Waukesha Co., Wisconsin, estimated the *possible* total consumption on various types of farms as follows.

Dairy farm	20 cows	3,180 K.W H. per annum.
	50 cows	6,000 K.W H. per annum
	100 cows	10,560 K W H per annum
Grain farm	50 acres under crop	2,365 K.W H. per annum
	100 acres under crop	2,725 K W H per annum
	200 acres under crop	3,480 K.W.H. per annum

Stock farms from 2,300 to 4,400 K.W H per annum.

The above figures include lighting of house, buildings and yard, electric range, milking machine and the usual farm and domestic appliances, and probably represent approximately the maximum possible development.

Comparative Costs of Rural and Urban Electric Services

The following table shows the relative cost of electric power to a farm consumer as compared with the cost of same to a resident in a medium size town of say 5,000 to 10,000 population.

It is assumed that each consumer will use 400 K. W. H. per annum, and the cost of generating the electricity at the power house switch board is taken at 4 cents per K. W. H. in each case.

The farm consumer is connected to a rural line costing say $1,120 per mile, and having three farmer consumers per mile. Each consumer is supplied through a 2 K. V. A. transformer.

The cost of the town distribution system is taken at $3,000 per mile, and it is assumed that there is an average of 55 consumers per mile of distribution line. This is approximately the average cost of distribution lines and number of consumers per mile in the larger towns (not including cities) in this province.

The urban consumers receive service from a 10 K. V. A. transformer which supplies 25 consumers.

Comparison Between Rural and Urban Consumers

	Farm consumer	Town consumer
Cost of line per mile	$1 120	$3,000
Number of consumers per mile	3	55
Capacity of transformer	2 K.V.A.	10 K.V.A.
Cost of transformer installed	$ 85	$185
Number of consumers per transformer	1	25
Average consumption per annum	400 K W H	400 K W H
Transformer core loss per consumer per annum	290 K W H	35 K W H.
Line loss per consumer per annum	40 K W H	20 K W H
Total transmission loss per consumer per annum	330 K W H	55 K W H
Cost of line per consumer	$280	$54 54
Cost of transformer per consumer	$ 85	$ 7 40
Cost of meter and service line per consumer	$ 50	$15 00
Total investment per consumer in line and service connection	$415	$76 94
Interest on capital invested per consumer at 5% per annum	$ 20 75	$ 3 84
Depreciation, maintenance and repairs 7½% per annum	31 12	5 77
Cost of current used by consumer	16 00	16 00
Transformer core losses	11 60	1 40
Line loss	1 60	80
Meter reading, billing, office expenses, etc	5 00	5 00
Total	$ 86 07	$32 81
Average monthly bill	7 17	2 73
Average cost of current per K W H	21½ cents	08¼ cents

It will be seen from the above table that the generation cost of current is only a small proportion of the cost of distributing it to the farm consumer Also that if the farmer used no current at all it would be necessary for him to pay $70 07 per annum or $5.84 per month to cover the overhead charges on the distribution system as compared with $16.81 per annum or $1.40 per month for the town consumer These charges would be in the nature of service charges in addition to an energy charge of 4 cents per K W H consumed

In practice, it may be found desirable to reduce the service charge and to provide for the balance of the overhead cost by an increased energy charge for the first block of power consumed.

Examples of Rural Power Rate Schedules

The following examples of rural rate schedules in actual use will be of interest

Ontario Hydro-Electric Power Commission

The Ontario Hydro-Electric Power Commission divides farm service into eight classes, and the monthly service charge varies according to the estimated maximum demand of each class of consumer, varying from $3.11 per month for small farm service for lighting buildings and power with an estimated maximum demand of 2 K W , up to $11.88 per month for large farm service including lighting of farm buildings and power for three-phase motors up to a maximum estimated demand of 15 K W To this is added the energy charge varying from 4 cents to 3 cents per K W H , according to locality for all current used up to 14 hours per month use of the maximum demand Current used in excess of 14 hours use of the maximum demand is charged at a uniform rate of 2 cents per K W H

Monthly accounts are subject to a discount of 10 per cent. for prompt payment.

The above rates have been in use since 1925, previous to that the rates were somewhat higher

It may be noted here that the Ontario Provincial Government bonuses the Power Commission up to 50 per cent. of its capital outlay on rural lines in other words the Government pays one-half the cost of installing rural service

Wisconsin

The Wisconsin Power and Light Company serves more than 40,000 farmers in the State of Wisconsin The company finances rural extensions up to an average cost of $400 per consumer, any cost in excess of this must be paid by the consumer

The following schedule of rates was approved by the Wisconsin Railroad Commission in June, 1926, and is considerably lower than

the schedule of rates previously in effect A monthly service charge is made proportionate to the transformer capacity required for each consumer, as follows

Transformer capacity required	Monthly service charge
1 1/3 K V A	$3
3 K V A	$4
5 K V A.	[redacted]
7½ K V A	$6

When three or four consumers are served from one transformer the service charge may be reduced. In addition to the service charge, an energy charge is made of 7½ cents per K W.H for the first 50 K W H. used per month and 3½ cents per K.W.H for current used in excess of this. A discount of half a cent per K W H is allowed for prompt payment.

The Milwaukee Electric Railway and Light Company supplies over 200 rural consumers in Waukesha, Wisconsin The rate charged includes a service charge of $2 per month for four or less active rooms, plus 40 cents per month for each active room in excess of the first four The service charge entitles the consumer to five K W H per month per active room All energy used in excess of this allowance is charged to the consumer at 3½ cents per K W H

South Dakota

The Renner Line, South Dakota, supplies 17 farms in the district. The service charge varies according to the peak load thrown on the line during the month, but averages about $8 per month per consumer In addition to the service charge of $8 per month, each consumer pays 5 cents per K W H. for the first 30 K W H used per month, and three cents per K W H. for all additional energy used.

R. N Blackburn, M.E.I.C.

APPENDIX No 10

Water Powers in the Province of Saskatchewan

(Compiled from information supplied by the Department of the Interior)

The following tables showing the water powers available in the Province of Saskatchewan includes only known water power sites or rapids and falls concerning which some information is available. In many cases power investigations have only been made at certain rapids or falls and have not yet been extended to cover the whole river. Further investigations may considerably increase the power possibilities of these rivers and may also reveal the possibility of combining certain natural drops into one development. Other rivers may also be shown to have power possibilities.

The flow and horse power available are given as "ordinary minimum" and as "estimated for maximum development." The "ordinary minimum flow" is based on the averages of the minimum flow for the two lowest periods of seven consecutive days in each year for seven years or less according to the length of the period for which records are available. The flow "estimated for maximum development" is based upon the continuous power indicated by the flow of the stream for six months in the year computed as follows. The months of each year are arranged according to the day of the lowest flow in each month. The lowest of the six high months is taken as the basic month, and the average flow of the lowest seven consecutive days in this month determines the ordinary six months flow for that year. The average of these figures for all the years in the period for which data are available is taken as the flow "estimated for maximum development."

The figures for horse power are calculated on the basis of 80 per cent efficiency.

A summary of the water powers in various Saskatchewan rivers is given hereunder.

Beaver River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet		H P at 80% Efficiency	
			Ordinary minimum	Estimated for maximum development	Ordinary minimum	Estimated for maximum development
Beaver River	6AG 1	27	320	940	785	2,300

BLACK RIVER—ESTIMATED FLOW AND POWER

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H P at 80% Efficiency: Ordinary minimum	H P at 80% Efficiency: Estimated for maximum development
Below Hatchet Lake	7LC 11	.8	500	1 500	820	2,455
Above Crooked Lake.	7LC 10	26	500	1,500	3,180	3,547
Above Waterfound River	7LC 9	10	500	1,500	455	1,365
Above Kosdaw Lake	7LC 8	20	970	2,900	1,760	5,275
Above Perpendicular Rock	7LC 7	.5	970	2,900	1,320	3,950
Thompson Rapid	7LC 6	38	970	2,900	3,350	10,000
Manitou Fall	7LC 5	42	970	2,900	3,700	11,300
Brink Rapid	7LC 4	25	970	2,900	2,200	6,590
Hawkrock Rapid	7LC 3	10	970	2,900	880	2,675
North Rapid.	7LC 2	15	970	2,900	1,320	3,955
Below Porcupine River	7LC 1	47	970	2,900	4,144	12,400
Elizabeth Fall .	7LC 12	120	1,966	5,900	21,400	64,300
Below Middle Lake	7LC 13	160	1,966	5,900	28,600	85,800
5M above mouth	7LC 14	8	1,966	5,900	1,430	4,290
				Total .	72,559	217,902

CHURCHILL RIVER—ESTIMATED FLOW AND POWER

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H.P at 80% Efficiency: Ordinary minimum	H.P at 80% Efficiency: Estimated for maximum development
Below Shagwenaw Lake	6BB 1	19	4,200	4,820	7,300	8,300
Pelican Rapids.	6BB 2	8	4,530	5,200	3,300	3,800
Birch Fall	6CD 1	18	5,680	6,520	9,800	10,700
Otter Fall. .	6CD 2	20	6,360	7,280	11,600	13,200
Keg. Island, Pine and Grave Rapids	6CD 3	35	7,950	9,130	25,300	29,100
Kettle Falls (1) .	6CD 4	30	8,020	9,210	21,900	25,100
Attik to Knife Rapids	6EA 1	70	22,600	28,400	143,900	180,700
Island Falls.	6EA 2	37	22,600	28,400	76,000	95,500
				Total	298,600	366,400

Foster River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum develop-ment	H P at 80% Efficiency: Ordinary minimum	H P at 80% Efficiency: Estimated for maximum develop-ment
30 miles above Sandy Creek	6CE 3	10	133	400	121	363
10 miles below Sandy Creek	6CE 2	15	215	650	295	885
6 miles above mouth of river	6CE 1	25	215	650	490	1,480
				Total	906	2,728

Geikie River—Estimated Flow and Power

Site	Index No	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum develop-ment	H.P at 50% Efficiency: Ordinary minimum	H.P at 50% Efficiency: Estimated for maximum develop-ment
5 M. below Big Sandy Lake.	7LA 6	15	100	300	136	409
2nd. Rap. above White	7LA 5	12	100	300	109	327
5 M. above White Spruce	7LA 4	30	100	300	272	818
White Spruce Rapid	7LA 3	38	100	300	345	1,036
2½ and 4 M. above Poor Fish R.	7LA 2	70	100	300	636	1,909
Below Poor Fish R.	7LA 1	45	233	700	953	2,860
				Total..	2,450	7,359

Mudjatik River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum develop-ment	H.P at 80% Efficiency: Ordinary minimum	H.P at 80% Efficiency: Estimated for maximum develop-ment
3 Miles above Grand Rapids	6BC 4	13	100	300	118	355
Grand Rapids and ½ mile above	6BC 3	14	100	300	127	382
10 mues above Bear Rapid	6BC 2	10	166	500	150	450
5 miles above Bear Rapid	6BC 1	12	166	500	180	545
				Total..	575	1,732

Rapid River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H.P. at 80% Efficiency: Ordinary minimum	H.P. at 80% Efficiency: Estimated for maximum development
Rapid Falls	6CB$_1$	57	900	1,100	4,660	5,700

Reindeer River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H.P. at 80% Efficiency: Ordinary minimum	H.P. at 80% Efficiency: Estimated for maximum development
White Sand and Rock Rapids	6DD$_1$	30	14,150	18,300	38,600	49,900
Devil's Rapid	6DD$_2$	9	14,150	18,300	11,600	15,000
Steep Hill Rapid	6DD$_3$	20	14,150	18,300	25,700	33,300
Deer Rapid	6DD$_4$	5	14,150	18,300	6,400	8,300
				Totals	82,300	106,500

Saskatchewan River—Estimated Flow and Power

Site	Index No.	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H.P. at 80% Efficiency: Ordinary minimum	H.P. at 80% Efficiency: Estimated for maximum development
Lacolle Falls	5GG$_1$	28	1,351	5,848	3,439	14,880
Mile 38¾	5KD$_1$	40	3,000	12,500	10,900	45,500
Mile 51½	5KD$_2$	40	3,000	12,500	10,900	45,500
Mile 70	5KD$_3$	55	3,000	12,500	15,000	62,500
Mile 84	5KD$_4$	40	3,000	12,500	10,000	45,500
Mile 101 5/8	5KD$_5$	30	3,000	12,500	8,200	34,100
Mile 161½	5KD$_6$	60	3,000	12,500	16,400	68,200
				Totals	75,739	316,180

Sturgeon-Weir River Basin—Estimated Flow and Undeveloped Power

Site	Index No	Head in feet	Flow in Second Feet: Ordinary minimum	Flow in Second Feet: Estimated for maximum development	H P at 80% Efficiency: Ordinary minimum	H P at 80% Efficiency: Estimated for maximum development
Grand Rapids	$5KF_1$	29	375	600	990	1,580
Birch Rapid	$5KG_1$	33	500	800	1,500	2,400
Scoop Rapid	$5KG_2$	12	500	800	545	875
Spruce Rapid	$5KG_3$	12	500	800	545	875
				Totals.	3,580	5,730

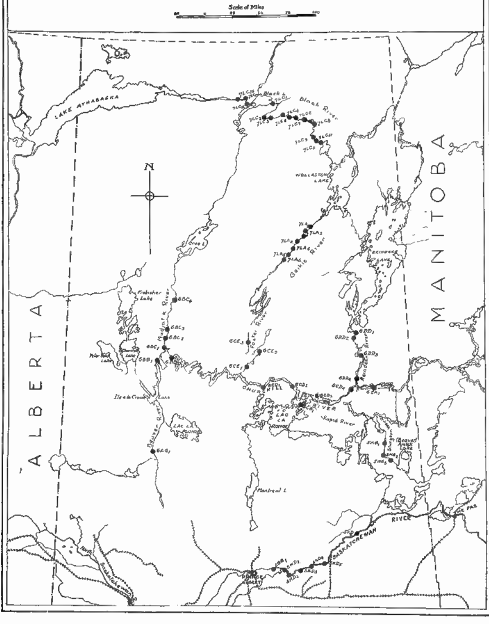
Note.—Site No. $5KF_1$ is an outlet from Lake Deschambault

Summary of Available Water Power in Saskatchewan

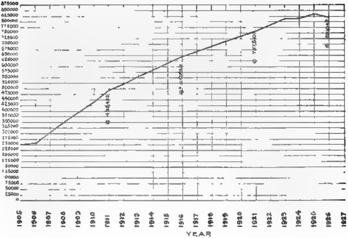
River	Horse Power at 80% Efficiency: Ordinary minimum	Horse Power at 80% Efficiency: Estimated maximum development
Beaver	785	2,300
Black	72,569	217,902
Churchill	298,500	366,400
Foster	906	2,728
Geikie	2,450	7,359
Mudjatik	575	1,732
Rapid	4,600	5,700
Reindeer	82,300	106,500
Saskatchewan	75,739	316,180
Sturgeon-Weir	3,580	5,730
Total	542,054	1,032,531

Appendix No. 10

MAP SHOWING WATER POWERS OF SASKATCHEWAN.



POPULATION OF SASKATCHEWAN FROM 1905 TO 1926



Note. ⊙ Figures are taken from Dominion Census.

TOTAL ELECTRICAL OUTPUT PER ANNUM
IN
SASKATCHEWAN

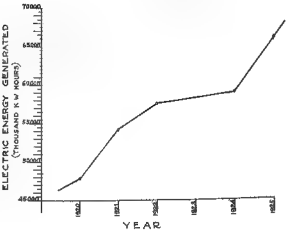


CHART SHOWING VARIATION OF LOAD DEC 25, 1926

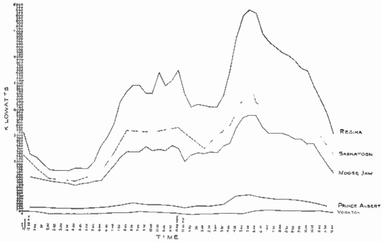


CHART SHOWING VARIATION OF LOAD JUNE 23, 1927

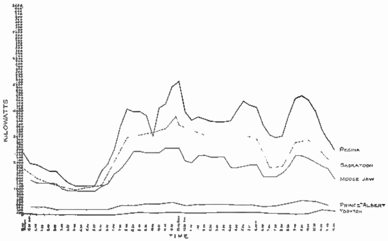


CHART SHOWING DAILY OUTPUT
FROM OCTOBER 1ST 1926 TO SEPTEMBER 30, 1927

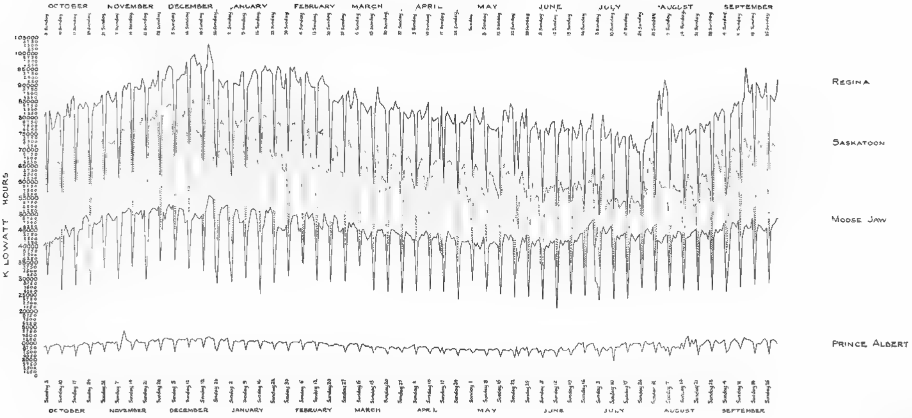


CHART SHOWING KILLOWATT HOURS GENERATED MONTHLY
THE CITY OF REGINA, LIGHT AND POWER DEPARTMENT

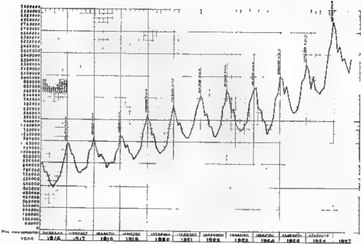
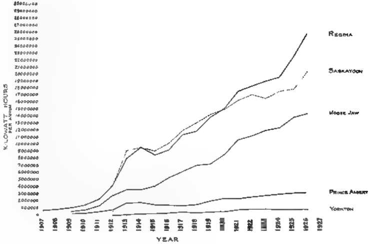


CHART SHOWING TOTAL YEARLY OUTPUT



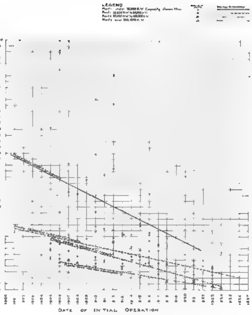


DIAGRAM showing 1 Historical Development in power plant fuel economy
2 The comparatively greater fuel economy of large plants

To the

Power Resources Commission

of the

PROVINCE OF SASKATCHEWAN

A Report on the "Economic Practicability of Centrally located Electric Power Stations in connection with a System of High Tension Transmission Lines to serve the more populous areas within the Province."

By

SULLIVAN, KIPP & CHACE, LIMITED

Consulting Engineers

WINNIPEG - - CANADA

TABLE OF CONTENTS

INTRODUCTORY

By the Legislature of the Province there was issued in 1927 a commission to Messrs. Louis A Thornton, Arthur Hitchcock and Alexander R. Greig with instructions to investigate and report upon the economic practicability of generating power at central power plants and water power sites in the province and the distribution of same throughout the province, and in particular, without restricting the generality of the foregoing terms, upon the following matters

1 As to the economic practicability of the construction of central power plants on the lignite coal fields of Southern Saskatchewan

2 As to whether it would be preferable in the alternative or in addition to No 1 to locate central power plants at other suitable points in the province with a view to the ultimate interconnection of these various central systems.

3 As to whether it is desirable that such central plants should be operated in conjunction with the production of char, briquettes and other by-products

4 The probable cost of power produced by such plant or plants, the distance to which such power could be economically transmitted and the price that would have to be charged for such power at the various points in the province to which it might be transmitted

5 The capacity of existing power plants in the province and their present output, present sale price of current and present cost of production

6 As to whether or not

(a) The development of transmission of power in Canada or elsewhere has tended to the electrification of the farms which are adjacent to the transmission lines and which can be served thereby

(b) The use of electricity on the farms has materially increased since the distribution of power in other provinces or elsewhere.

(c) The transmission of power in this province would create a material demand from the farming communities for electrical energy

As to whether it would be desirable to utilise existing pole lines in the province for the transmission of power in rural districts and sparsely settled localities

7 Whether or not it would be advisable for municipalities owning and operating power plants to be granted the privileges of selling energy outside the corporate limits of the municipalities and for such purpose to be granted power under provincial regulations to construct, own and maintain power transmission lines outside the limits of the corporation and interconnected with existing plants.

8 As to what, if any, hydro-electrical possibilities there are in the province

9 As to whether it would be possible under existing conditions to develop any of these water powers to economic advantage

10 As to what type of construction of transmission and distribution lines would be most suitable to conditions prevailing in this province.

11 As to whether there is at present a sufficient market for the power which would be produced at any such central power plant or plants.

12 As to whether, if there is not such a market at present, the production of power at such plant or plants and the sale thereof at a low rate would, in the opinion of the Commission, create a demand for such power

Our Instructions

By letter of September 23, 1927, addressed to your consulting engineers instructions were issued by your Commission that of the above schedule studies should be undertaken of questions numbers 1, 2, 3, 4, 8, 9, 10, 11 and 12 your letter reads in part as follows

"The duties of the Power Resources Commission are outlined in an Order-in-Council copy of which you have, and from which you will note that the work of the Commission is to advise the Government on some particular questions relating to the power situation in the province We are not in any way directed to develop any of the resources of the province, but our work will be merely of an advisory nature, and we trust will be the basis of further work either by the Government or some other party in the province From this you will understand that we do not wish to discuss the whole situation in the same detail as would be necessary if actual development were in immediate prospect and on this account the enquiry can be restricted somewhat.

"Referring to the questions outlined in the Order-in-Council we have discussed the same in detail with your Mr Chace, and we desire you to direct your attention particularly to the questions, as follows

"Question No. 1 In this connection a great deal of development has taken place at Estevan or in the vicinity representing very large expenditure in money, and it would appear that the location of Estevan or thereabouts should be carefully studied in connection with question number one There are, however, one or two other locations in the province south of Moose Jaw which have been referred to, and these locations should be at any rate taken into account

"Question No. 2 should be discussed, and we feel is sufficiently explicit without further elaboration.

"We would also direct your attention to question No. 3 We have no wish to enter into the discussion of the utilization of these coals to the extent of extracting various by-products or carbonization

of the coal and so forth. A great deal of data is already on hand in this connection for our purposes however, we are interested in the possibility of the drying of coal in connection with the waste heat from the power plant boilers.

"Question No. 4 is sufficiently explicit and we would wish you to deal therewith.

"Question No. 8 dealing with the hydro-electric possibilities in the province is one to which we would draw your attention, but wish that you would limit your discussion thereof very largely to the immediate prospects as to the possibility of development on the Saskatchewan river at La Colle Falls or near the forks of the two branches of the river. Some reference may be made to the possibilities in the far north of the province for informative purposes, but we do not consider this latter source is of immediate interest.

"Question No. 9 is a supplement to question No. 8.

"Question No. 10 should be dealt with, and speaks for itself.

"Questions Nos. 11 and 12 should be considered together and we would ask you to undertake this consideration. We have prepared a great deal of data as to the existing market, which will be given you together with data as to the load conditions in the existing plants and the history of the growth of the loads in these plants. We would consider that for the purposes of the report, attention should be given to the possible growth throughout the province a number of years hence and we would suggest that the period up to the year 1935 be the period to be discussed.

"We have discussed with Mr. Chace a rough outline of an interconnection of the larger centres of the province the first outline being from Prince Albert on the north through Saskatoon, Moose Jaw, Regina, Weyburn to Estevan on the south and in the alternative, from Prince Albert on the north through Melfort, Humboldt, Watrous, Regina, Weyburn and Estevan on the south. This latter line would involve branch lines to Saskatoon and Moose Jaw. In addition to this main interconnection we would like you to study the possibilities of a branch from Regina through Indian Head, Melville, Yorkton to Kamsack with a connection to Canora, and also a branch from Saskatoon to North Battleford either by way of the C. N. line north of the river or by way of Biggar.

"In respect to the water power question we have been assured by the representative of the Water Power Branch, Mr. Attwood, of Winnipeg, that the Department will place at your disposal any information on hand and will further be ready to assist in the investigation."

Information Had

From time to time we have received from your Commission details, summaries and graphs of data accumulated by you from the cities, towns and villages of the Province. We have obtained also certain other information direct from the officials in charge of the electric utilities. Without incurring great expense for surveys,

borings and other explorations we have informed ourselves of all available facts needed for our studies.

To permit definite choice of the most desirable central station site there will be needed

(a) A considerable series of surveys for water storage sites along the Souris River and its branches.

(b) A thorough underground exploration of the dimensions extent and continuity of the coal seams near Lake-of-the-Rivers.

Preliminary Designs Sufficient

Detailed designs of dams and of power houses needed for water power development along the Saskatchewan River, and of central steam station buildings and facilities have not been prepared, but in each case the designs have been sufficiently developed and sufficient inquiries regarding machinery and equipment have been extended to permit quite accurate estimates to be prepared covering the capital and operating costs of each construction studied.

Data regarding city electric utilities and concerning existent transmission systems in other provinces of Canada have been obtained by courtesy of Company and City Officials and of Commissions in Ontario and Manitoba, certain of this information is included within the report as illustrative of the probable eventualities of a central Saskatchewan system of power generation and distribution.

Our conclusions and recommendations are presented first, followed by the data and the arguments upon which the conclusions have been determined.

Preliminary Report

Under date of January 21, 1928, there has been presented to you a summary report including the principal conclusions and recommendations, along with certain of the arguments supporting (1) the rejection of the idea of early water power development, and (2) the urgency for early installation of a large central steam-electric station along with its necessary transmissions to reach the three principal cities. Certain quotations from that report are here included.

"Our studies have proceeded to such a point that we are able to present the following conclusions.

1. Hydro-electric constructions and transmissions therefrom are not recommended."

2. Supply of energy from a central steam station to the three principal cities and intermediate towns, villages, etc., of the province is recommended for the very near future."

3. "Immediate relief can be rendered to Saskatoon by prompt construction of that portion of the transmission system which would connect that city with Moose Jaw and Regina, thus permitting a pool of joint present city generating equipment."

4. Whatever central station be chosen, this transmission section will be incorporated as the nucleus of the entire system."

5 "Expansion of the mileage of transmission beyond those cities to serve outlying cities and groups of towns should be undertaken as it may from time to time be proven that sufficient economic advantage may accrue to those towns without detriment to the core of the system and without increase in its operating costs "

6 Provision should be made in the selection of site and in the design of the steam-electric generating station which will permit expansion to at least 50 000 kilowatts of capacity without increasing the capital costs per kilowatt, similarly main line transmission structures should permit of erection of a second circuit so that jointly the circuits shall have capacity corresponding to that of the enlarged steam station."

7 "Enabling legislation should be provided by the Government of the Province at once to give effect to these recommendations "

Further quotations—being discussions submitted with the preliminary report—will be found in the argument following.

From the studies hereinbelow it would appear

1 That the average cost of energy to be delivered to the three cities during 1930 would be less than the present costs on the bus bar at Moose Jaw and at Saskatoon, but slightly more than those at Regina

2 That the average costs of delivered energy during 1935 and subsequently would be much less than the 1926 costs at all cities, and less than can be hoped for by use of individual city plants by 1935

3 That the other advantages which would accrue to each of the cities by virtue of a Central Station Transmission scheme are quite sufficient to warrant the joint project.

4 That there is no warrant for early construction of the Prince Albert Branch (No 3) arising out of benefits to be derived by the major centre of population, that the desirability of Branch No. 2—to North Battleford is doubtful, and that the early inclusion within the scheme of a Branch (No 1) toward Kamsack is warranted on economic grounds.

We have therefore to add the following recommendations

8 That no time be lost in establishing the Tri-City Power Pool and the Central Station High Tension Transmission Project.

9 That, in view of the initiation of the westerly portion of the mileage of Branch No. 1 by a private corporation, that work be taken over and extended—at the higher voltage—to Kamsack and intervening towns.

10 That, in view of the slight differences in capital cost and in costs per delivered kilowatt hour which appertain to the three central station sites, there should be instituted at once a thorough investigation into

(a) The possibilities and costs of season to season storages on the Souris River above Roche Percee, which storages

must be provided for if a capacity greater than 25,000 kilowatts can be served there with enough of condensing water

(b) The extent, the thickness of seam, and the costs of mining lignite coal at Lake-of-the-Rivers, the favourable proof of these items being a *sine qua non* for choice of this site for a central steam-electric station.

11 That, unless the results of investigations shall prove favorable to the choice of Roche Percee or of Lake-of-the-Rivers as a site for a station of at least 50,000 kilowatt capacity, then the Elbow site shall be chosen

12 Pending the results of investigations recommended in Section 10 hereabove plans and specifications can be set in hand as soon as decision is reached to establish the Joint System

The instructions received by your engineers did not require the discussion of any specific plan of partnership among towns and cities which might enter a power pool It is fairly evident however, that into such a pool the Provincial Government should enter on behalf of those towns, villages hamlets and farms which would be within the area traversed by the transmission lines and branches. Or the Government, either directly or through a contracting power company might sponsor the entire project, selling energy at proper distribution voltage to customer towns and cities under term contracts In our preliminary report immediate permissive legislation was recommended which would open the way for the establishment of the power pool during 1928 by the cities and towns interested

The argument upon which these recommendations are based follows at considerable length The data available regarding power loads, present city generating station economics fuel supplies and costs, river flow quantities and history and other such pertinent information, is set out at the appropriate positions as tables and graphs throughout the discussion Estimates of capital costs and operating costs, both aggregate and per kilowatt-hour of energy delivered have been prepared and appear as proper elements of the argument Certain maps and sketches of typical steam station, transmission line, water power developments, and electrical layouts are attached at the end of that portion of this report

Believing that this report presents a proper and complete view of the problem, although arranged in somewhat different order from the series of questions and that the conclusions presented herein are sound.

We remain,

Your obedient Servants,

SULLIVAN, KIPP & CHACE, LIMITED,

Per W G CHACE, M.E.I.C

Winnipeg, Man., March 1, 1928

Report to Power Resources Commission

PROVINCE OF SASKATCHEWAN

ARGUMENT

SASKATCHEWAN—CENTRES OF POPULATION

Saskatchewan, an agricultural province of Canada, is possessed of few cities, widely scattered, of not many towns, also widely separated, and a multiplicity of hamlets and villages located at fairly regular intervals along the railway lines which cross the province The cities and the larger towns have had a record of rather rapid growth The present functions of the cities are chiefly those of distributing centres, also financial, governmental, and to a lesser extent, manufacturing It seems probable that the three larger cities will grow in population and importance at rates greater than those to be experienced by the smaller cities and the larger towns, similarly the towns will probably outdistance the villages in rate of increase, with the exception of such as may be affected by special local conditions

As evidence of the statements made above, reference is made to Table No. 1 in which is set out the recent story of the changes in population of the seven larger centres since 1922 The following Table No 2 will indicate that the tendency is for relatively small changes in population in the towns and villages.

Table No 1.

RECORD AND STUDY OF POPULATION GROWTHS IN SEVERAL SASKATCHEWAN CITIES

	Battleford and North Battleford	Estevan	Moose Jaw	Prince Albert	Regina	Saskatoon	Yorkton
1922	5,337	2,290	19,285	7,553	34,482	25,739	5,151
1923	5,300	2,450	20,225	8,087	36,842	27,540	5,511
1924	5,475	2,450	20,498	7,100	36,842	27,540	5,511
1925	5,450	2,519	21,213	7,100	37,875	28,212	5,606
1926	5,805	2,336	19,039	7,873	37,329	31,234	4,458
Future Increases of Population Estimated on the Basis of 5 per cent. per annum.							
1930.	7,050	2,720	23,200	9,550	45,600	38,000	5,450
1935.	9,000	3,680	29,500	12,200	58,000	48,500	6,900
1940.	11,500	4,630	37,700	15,600	73,900	61,900	8,830
1945	14,600	5,880	48,000	19,800	94,200	78,700	

Future Increases of Population Estimated on the Basis of 3 per cent. per annum

1930	6,540	2,630	21,450	8,870	42,100	35,200	5,020
1935	7,660	3,080	25,100	10,380	49,300	41,200	5,870
1940	8,950	3,590	29,300	12,100	57,500	48,200	6,860
1945	10,450	4,210	34,400	14,200	67,300	56,400	8,050

1926 Populations from Dominion Census, others from Assessor Records.

TABLE No 2

	1922	1923	1924	1925	1926
Arcola	606	648	679	666	685
Broadview	839	896	877	923	781
Canora	1,230	1,320	1,009	1,353	1,121
Carnduff	494	494	483	494	537
Craik	570	610	629	627	603
Davidson	652	652	638	657	602
Duck Lake	437	467	472	481	587
Govan	495	530	530	525	456
Gravelbourg	1,106	1,183	846	1,217	1,201
Grenfell	705	790	725	740	699
Humboldt	1,822	1,700	1,584	1,584	1,751
Indian Head	1,439	1,540	1,396	1,583	1,313
Kamsack	2,002	2,142	2,011	2,015	1,948
Kindersley	1,003	1,073	1,006	1,104	987
Leader	465	818	539	600	526
Maple Creek	1,001	1,071	1,000	1,100	930
Moosomin	1,099	1,100	1,176	1,100	1,121
Melfort	1,746	1,868	1,663	1,700	1,605
Outlook	704	753	763	775	634
Qu'Appelle	688	736	725	725	640
Sutherland	961	900	866	900	1,010
Watrous	1,101	1,100	1,169	1,169	1,172
Wolseley	956	1,023	1,023	1,000	944

A Few Towns Show Recent Growth

Assiniboia	1,006	1,210	1,300	1,405	1,245
Biggar	1,535	2,000	2,032	2,100	2,034
Gull Lake	788	843	854	850	908
Melville	2,308	3,004	3,004	3,089	3,352
Radville	883	945	946	971	1,082
Rosthern	1,074	1,149	1,394	1,181	1,273
Shaunavon	1,146	1,226	1,226	1,500	1,459
Unity	611	654	654	672	747
Wilkie	778	832	832	856	1,041

GROWTH OF ELECTRICAL REQUIREMENTS

The consumption of electricity in the cities of Saskatchewan has increased at a rate much more rapid than the increase in population. A similar phenomenon has been experienced all over Canada and the United States, and the consumption per head of population in all centres is yet increasing. The cities of Saskatchewan, being without domestic gas supply, absorb electric energy at a very liberal rate, not altogether dependent upon the price charged

We have the following facts regarding Regina

	Total Kwh.	Kwh. per head of population
1907	833,058	
1912	4,347,293	
1917	11,652,367	
1922	18,439,000	536
1923	19,053,160	517
1924	19,661,700	533
1925	22,529,550	595
1926	25,350,570	694
1927	17% increase over 1926 to November	

Regarding Saskatoon:

	Kwh. sold	
1924	14,662,798	
1925	15,102,324	
1926	17,487,566	10,516,949 (8 months)
1927		12,123,599 (8 months)

	Kwh generated	Kwh. per head	Meters
1924	16,494,070	600	11,565
1925	16,818,690	595	12,016
1926	19,256,930	616	12,975
1927	22,000,000		14,176

(Estimated by Commissioner.)

Regarding Moose Jaw

	Kwh sent out from the plant
1925	11,421,304
1926	12,752,312

	Number of active Accounts
1925	4,934
1926	5,333

	Total Kwh. generated	Per head of population
1922	11,387,200	592
1923	12,139,600	600
1924	12,502,800	610
1925	13,962,500	657
1926	14,489,200	683

The increase in energy sales has been in large part due to the freer use of domestic electric utensils. There is considerable room for increase in this energy requirement and an active sales campaign in all of the cities would result in this increase becoming commercially valuable at proper rates.

Regina with 6,934 domestic services, has 1,815 of them equipped with electric range, water heater, refrigerator or combinations of these in 1926. Of ranges there are 1,900 and of water heaters 100 connected.

Saskatoon, with 6,955 domestic light services, has 978 domestic power services in 1926, an increase over 1925 of 17.3 per cent. in the latter against 2.6 per cent. in the former.

Moose Jaw with 4,385 residential consumers, has 744 ranges, 30 water heaters, 22 refrigerators, 1,600 washers, 3,300 irons, 3,500

vacuum cleaners and sundry other electricity consuming devices on the lines.

The smaller cities and towns have relatively fewer electric power consuming devices connected, Prince Albert has 64 ranges, Weyburn 68 and expected to have 90 by the end of 1927

Table No 3 is a study of the electricity consumption in Saskatchewan cities, towns and villages.

SASKATCHEWAN TOWNS—ELECTRIC DEMAND AND CONSUMPTION

Table No. 3

Town	Over 3,000 people			Over 900 people			Under 900 people		
	Population	K W H	K W H per head	Population	K W H	K W H per head	Population	K W H	K W H per head
Assiniboia				1,405	167,623	119			
Avonlea							320	(3 months)	
Arcola							666	40,000	60
Balcarres							468	20,100	43
Balgonie							224	7,509	33
Briercrest							192	7,000	36
Battleford				1,000	185,840	186			
Broadview				923	42,268	46			
Craik							627	22,000	35
Carlyle							407	19,080	47
Cupar							325	15,721	48
Davidson							657	102,263	153
Duck Lake							481	5,100	11
Estevan				2,519	702,888	279			
Eyebrow							267	12,650	47
Elrose							300	(2 months)	
Govan							525	26,048	50
Hanley							343	4,000	12
Herbert				1,000	56,311	56		.....	
Humboldt				1,584	384,349	242			
Indian Head				1,583	156,560	99			
Ituna							368	7,700	21
Kipling							403	16,980	42
Kamsack				2,015	494,199	247			
Lancer							135	4,800	35
Lang							341	21,000	62
Langham							430	24,651	55
Lashburn							364	22,500	62
Lemberg							472	7,510	16
Leslie							178	400	2
Lumsden							518	19,820	38

SASKATCHEWAN TOWNS ELECTRIC DEMAND AND CONSUMPTION—*Continued*

Town	Over 3,000 people			Over 900 people			Under 900 people		
	Population	K W H	K W H per head	Population	K W H	K W H per head	Population	K W H	K W H per head
Loverna							222	6,000	27
Morse							600	25,000	41
Melfort				1,700	339,621	200			
Melville	3,089	304,950	99						
Moose Jaw	21,213	12,752,312	600						
North Battleford	4,450	1,260,814	284						
Oxbow							600	23,596	40
Pelly							225	10,000	44
Prince Albert	7,100	3,174,733	447						
Qu'Appelle							725	28,000	39
Radisson							431	24,550	57
Radville				971	41,416	42			
Raymore							270	11,266	42
Redvers							170	6,041	35
Rosetown				950	160,448	169			
Regina	37,875	24,523,155	648						
Readlyn							120	2,298	19
Saskatoon	28,312	19,256,980	682						
Semans							495	25,000	50
St Boswells							160	5,013	31
Star City							657	41,726	64
Strasbourg							501	30,900	60
Sutherland				900	11,580	12			
Scott							224	34,200	153
Shaunavon				1,500	363,105	242			
Swift Current	3,869	1,257,400	325						
Tisdale							861	78,160	91
Tompkins							279	14,000	50
Tugaske							253	6,100	24
Unity							672	72,460	107
Vanguard							306	8,150	27

Vonda							421	23,949	59
Watson							436	6,113	14
Wilcox							299	15,443	51
Wilkie							856	93,332	109
Wolseley				1,000	75,730	76			
Wynyard				928	51,800	56			
Young							370	15,000	40
Yorkton	5,066	838,736	148						
Yellowgrass							490	44,600	90
Totals	111,574	63,368,080	568	19,978	3,183,758	159 4	19,024	1,057,724	55 5

Comparison With Ontario and Other Experiences

Table No. 4 sets out the number of customers and the peak demand per head of population of the cities of Ontario which are of size similar to those of Saskatchewan. These cities as a rule have been supplied from a power pool under joint municipal control for from ten to twenty years and at rates for energy much lower than those prevailing in Saskatchewan.

Certain western statistics are set out in comparison

Table No. 4.

ELECTRIC DEMAND IN ONTARIO CITIES

1926 Demands for Electric Energy

(Report of Hydro-Electric Commission of Ontario)

City	Population	Peak H.P.	Customers	Per cent. of population	H P Peak per head of population	Cost per H.P to city
Brantford	28,010	8,829	6,515	23.2	0.315	$27.00
Guelph	19,219	6,709	5,272	27.4	0.349	27.00
Hamilton	122,238	34,339	30,091	24.6	0.281†	25.00
Kitchener	24,805	12,372	6,538	26.4	0.263	27.00
London	63,339	24,810	18,392	29.0	0.391	26.00
Niagara Falls	16,819	8,539	4,654	27.7	0.505	19.00
Ottawa.	118,088	17,728	12,897	10.9	0.150†	11.50
Port Arthur	17,021	25,670	4,203	24.7	1.510*	21.00
St. Catherines.	21,810	7,018	5,829	26.7	0.321	21.00
Stratford	18,888	5,490	4,832	25.6	0.281	30.00
Windsor	52,638	24,885	15,519	29.5	0.473	30.00
Toronto	542,187	220,676	150,096	27.7	0.388	24.00
†Market shared with private company						
*Large Industrial Customers.						
Compare						
Moose Jaw	21,213	5,270	5,333	25.1	0.249	$78.40
Prince Albert	7,100	1,207	1,900	26.8	0.170	91.00
Regina	37,875	10,720	9,629	25.4	0.283	41.60
Saskatoon	28,312	8,050	9,536	33.7	0.284	62.10
and.						
Calgary	65,513	19,906	18,364	28.1	0.304	
Lethbridge	11,097	1,790	2,683	24.2	0.161	
Edmonton	65,163	16,000	17,786	27.4	0.246	
Brandon, Man..	16,880	1,800	2,508	14.8	0.107	

In Table No. 5 are set out the 1924, 1925 and 1926 peaks of demand for electricity in eleven Ontario cities, the growth of the demand is indicated. A similar phenomenon is experienced in all United States cities, as also to an equally large extent in Winnipeg

Table No. 5.

Growths of Power Loads in Ontario Cities
(From Report of Hydro-Electric Power Commission for 1926)

Peak Loads in Horse Power for October

City	1924	1925	1926
Brantford	7,385	8,400	9,085
Guelph	6,122	5,889	6,208
Hamilton	28,954	27,397	31,672
Kitchener	10,482	11,353	11,969
London	17,418	19,114	22,317
Niagara Falls	6,106	6,914	7,821
Ottawa	13,206	14,260	16,355
Port Arthur	21,841	26,407	26,541
St. Catharines	6,314	6,274	7,335
Stratford	5,406	5,262	6,454
Windsor	15,933	18,461	22,986
Totals 11 cities	133,667	149,731	168,743
Toronto	124,662	179,405	195,759

Growths of October Demand	1924–5	1925–6
11 Cities	16,064 12%	19,012 12.6%
Toronto	54,733 44%	16,854 9%

Table No. 6 shows the 1926 consumption of energy by eleven Ontario cities and the rates charged for energy

Table No 6.

1926 Operating Statistics for 12 Ontario Cities
(From Report of Hydro-Electric Power Commission of Ontario)

All Bills Subject to 10 per cent. (or more) Discount

Domestic Light

City	Consumption Kwh	Service charge	Rates (cents/Kwh)		
			Block 60 Kwh		Additional Kwh.
			(*)1st.	(†)2nd.	
Brantford	8,223,516		3	2	1
Guelph	4,243,310	33	.	2	1
Hamilton	33,971,963		3	2	1
Kitchener	8,468,365		3	2	1
London	21,752,627		3	2	1
Niagara Falls	9,639,182		3	2	1
Ottawa	24,037,474	.	3	2	1
Port Arthur	4,984,041		3	2	1
St. Catharines	7,613,558		3	2	1
Stratford	7,218,750	33		2 5	1 25
Windsor	27,385,057	33	.	2 5	1
Toronto	135,202,113	.	3	2	1

Commercial Light

City	Consumption Kwh	Rates (cents)		
		1st Block		Additional Kwh.
		Kwh./mo.	Rate	
Brantford	2,234,309	50	3 5/1.75	0 35
Guelph	1,733,216	100‡	2 0	. 0
Hamilton	9,119,117	60	3 5/1 75	0 35
Kitchener	4,138,879	100‡	2 0	1 25
London	8,768,725	100‡	2 0	1 25
Niagara Falls	3,306,473	30	4 0	0 4
Ottawa.	6,915,874	100‡	3 5	1 75
Port Arthur	2,470,652	30	5.0	0 5
St Catharines.	1,462,146	30	3 5	0 35
Stratford	1,558.155	100‡	3 0	1 5
Windsor	8,863,598	100‡	2 5	1 25
Toronto	30,262,379	70	4 0	1 0

(*) Service charge per 100 sq. ft
(†) Per Kwh. per 100 sq ft
‡ Service charge per 100 watts/mo.

Power

City	Service charge per H P./mo.	50 hour blocks, Cent, Kwh Rate		
		1st	2nd	All over 100 Kwh
Brantford	$1 00	2 1	1 4	0.33
Guelph	1 00	1 5	0 9	0.33
Hamilton	1.00	1 67	1 11	0 15
Kitchener	1 00	1 9	1.3	0 33
London	1 00	1 8	1 1	0.33
Niagara Falls	1 00	1 83	1 233	0 156
Ottawa	1 00	1 8	1.2	0 50
Port Arthur	1 00	1 75	1.0	0 10
St. Catharines.	1 00	1 867	1 267	0 16
Stratford	1.00	2 6	1 7	0 33
Windsor	1 00	2 5	1 6	0 33
Toronto	1 00	1 5	0 75	0 40

Table No 7 is a study of the consumption per head of population in towns and villages of Ontario for 1926.

Table No 7.

KILOWATTS OF DEMAND AND, FOR DOMESTIC AND COMMERCIAL LIGHTING ONLY, KILOWATT HOURS CONSUMED IN SMALLER ONTARIO TOWNS 1926

Report of Hydro-Electric Power Commission of Ontario

Town	Population 1926	Consumers	Under 900 population					Population 900-3,000				
			H.P	Kw. per head	Kwh. 1920	Kwh 1926	Kwh. per hd 1926	H P	Kw per head	Kwh 1920	Kwh. 1926	Kwh. per hd 1926
Acton	1,810	520						535	0.22	117,194	439,175	243
Ailsa Craig	478	135	100	0.16	21,281	55,395	116					
Alvinston	653	156	76	0.08	43,111 (1923)	75,521	115					
Aylmer	2,145	674						456	0.16	167,779	618,443	288
Balls River	616	171	113	0.14	60,743 (1923)	106,297	173					
Blenheim	1,559	546						309	0.19	131,124	385,574	247
Blyth	623	151	61	0.07	44,813 (1925)	57,868	93					
Bolton	622	176	118	0.14	37,952	64,670	104					
Bothwell	665	224	188	0.21	31,698	116,262	175					
Brussells	859	208	106	0.09	111,169 (1925)	128,204	149					
Caledonia	1,890	260						233	0.125	64,339	228,012	164
Cayuga.	710	110	106	0.110		51,119	73					
Clifford...	497	105	44	0.068	31,600 (1925)	37,724	76					
Clinton	1,946	606						328	0.125	170,560	469,010	241
Drayton	572	193	80	0.104	36,272	82,145	143					
Dresden	1,421	450						343	0.180	101,863	240,662	169
Dutton	811	269	189	0.174	51,133	153,137	189					
Dunnville	3,464	660						599	0.129	227,334	536,512	155
Elora	1,079	385						252	0.174	107,268	234,996	218
Embro	476	132	61	0.096	20,028	66,409	139					
Erieau .	196	97	27	0.102	16,320 (1925)	28,554	145					

Report of Hydro-Electric Power Commission of Ontario—Continued

Town	Population 1926	Consumers	Under 900 population H.P	Kw per head	Kwh. 1920	Kwh. 1926	Kwh per hd 1926	Population 900-3,000 H.P	Kw per head	Kwh 1920	Kwh. 1926	Kwh per hd 1926
Exeter	1,583	524						314	0.148	84,681	385,364	243
Fergus	1,747	585						496	0.21	110,050	420,407	242
Forest	1,427	572						217	0.16	66,968	267,027	185
Georgetown	2,071	752						653	0.28	217,602	569,477	276
Glencoe	821	283	134	0.12	56,036	97,008	118					
Hagersville	1,193	552						457	0.27	110,128	256,526	215
Harriston	1,225	379						235	0.14	75,816	188,752	154
Humberstone	1,917	431						208	0.12	233,252 (1925)	281,719	152
Highgate	396	127	107	0.20	17,306	56,542	143					
Jarvis	459	100	158	0.25	36,758 (1925)	40,858	90					
Markham (rural)	968	290						119	0.092	36,864	120,586	125
Milverton	1,017	259						536	0.392	68,397	157,996	155
Newbury	285	81	29	0.074	14,919 (1922)	21,325	75					
Rodney	706	251	102	0.107	28,030	80,970	114					
Sutton	880	336	78	0.066	52,661 (1924)	98,140	1.1					
Stouffville	1,066	308	.	. . .				117	0.081	69,364 (1924)	112,020	103
Thedford	516	156	45	0.065	27,341 (1923)	49,932	97		.	.		.
Tecumseh	1,710	485	. .	.				177	0.077	93,772 (1923)	463,666	271
Watford	1,010	334						145	0.107	47,865	208,923	207
Wheatley	665	199	100	0.122	68,034 (1925)	99,221	149					
Wyoming	460	157	49	0.080	23,140	46,371	101					
Average Weighted				0.119			128.5		0.162			207

Table No 8 gives similar statistics for Manitoba villages now served by the Provincial Transmission System

Table No. 8.

Prospective Development of Energy Sales in Smaller Communities

This development may be gauged to some extent by the experience of the Provincial Power Commission of Manitoba. The following information has been made available to your engineers by that Commission, who state that the population of the communities has been practically stationary for many years.

Town or village	First energy supply	1927 Record				
		Population	Customers	Per cent. rates	Kwh.	Kwh. per head
Portage la Prairie	1920	6,513	1,200	18 3	1,842,637	283
Carman	1921	1,385	348	25 2	315,600	228
Roland	1921	487	164	31 6	105,520	226
Morden	1921	1,354	365	26 9	298,200	220
Oakville	1922	315	94	29 8	27,714	88
Elm Creek	1922	415	77	18 5	66,820	160
Virdon	1921	1,378	414	30 0	242,154	174
Minnedosa	1921	1,682	411	24 4	226,870	135

Growth of Municipal Electric Facilities

The municipal utilities and facilities necessarily have been developed in parallel with the growths of the cities and towns. In each principal city the electric light and power generating equipment now in use is an accumulation of units of various dimensions, the rating of each unit being a definite indicator of the order in time of its purchase and installation. The largest unit in each station, the latest and most efficient therein, is in each case at present insufficient in capacity to carry the peak load upon the local system. The latest unit installed approaches in dimension that which is capable of the maximum modern efficiencies experienced elsewhere, in each of the three principal city stations the units less recently installed have much lower operating efficiencies, generally the over-all efficiencies are moderate to poor, although constantly advancing due to the skill and attention of the superintending staffs, improvements being attained by care in selection of newer equipment items and in maintenance and rebuilding of furnaces and auxiliaries.

As an example the electrical equipment in Saskatoon station has been developed as below

1912—Allis-Chalmers Turbo-Generator, 2,000 Kw @ 1,800 Rpm.
1914 —Westinghouse Turbo-Generator, 4,000 Kva. @ 3,600 Rpm.
1921 Westinghouse Turbo-Generator, 6,250 Kva. @ 3,600 Rpm.

That in the Regina station has the following history
1912—Siemens Turbo-Generator, 1,500 Kw @ 1 800 Rpm
1915—Siemens Turbo-Generator, 3,000 Kw @ 3,600 Rpm
1920—General Electric Turbo-Generator 6 250 Kva @ 3 600 Rpm
1925—General Electric Turbo-Generator, 6,250 Kva @ 3,600 Rpm

The steam economies of the larger of all these units and of the new 5,000 Kw Moose Jaw unit are set out elsewhere in this report. The tendency is for improved performance in the later generators. The steam boiler plants in the Saskatchewan cities have undergone a similar history—of beginnings with relatively small outputs and low steam pressures, and old-fashioned furnaces—and advancing in all these items as larger and more up-to-date steam generators were purchased

The boilers most lately installed (and rebuilt) in the Regina station will operate at 200 pounds pressure and will deliver steam at 700° Fahr , earlier ones still in use deliver steam at 550° Fahr. A special arrangement of economisers is installed, but no air heaters, the boilers are soon to be fed with powdered fuel

The boilers in the Moose Jaw plant are to be replaced at once with up-to-date and more efficient units

Those in Saskatoon, equipped with Jones' stokers, operate at 150 pounds pressure and 50° Fahr superheat A new station is planned

Electric Station Capacities Must be Increased Frequently

The recent records of output from the power stations in the three principal cities already indicate that in the near future the present capacities of these stations will be exceeded, and by a constantly increasing quantity per year For instance, the output of the Regina station for 1927 has been for eleven months 17 per cent. greater than for the corresponding period of 1926 The year's total will thus approach 29,000,000 Kwh , an increase of about 4,500, 000 Kwh Each year the quantity of increase will be larger—because of the natural and probable—increase of population and because the use of electricity per head is increasing annually

Even a uniform percentage increase is annually built upon a larger annual consumption, and the gross requirements are now reaching such dimensions that additional generating units must repeatedly be of larger capacity per unit The only option to a rapidly growing capital investment in steam-electric stations by each of the Saskatchewan cities is the adoption of the principle of co-operative building of a relatively large central station, which would be equipped with modern boiler and turbine units of larger unit dimensions than would be selected for individual city stations

General Advantages of Joint Central Station Policy

A site can be chosen at which is possible expansion to such great capacity as may be required for a reasonable period of years

Such a site should have good railway service, reasonable fuel costs, ample condensing water supply, and for several reasons should not be far from the centre of gravity of the combined electric loads

In the future as the transmission network may be extended, as the maintaining of reliable and continuous service becomes super-important and as the centre of gravity of the load upon the system may shift after the transmission circuits shall have been duplicated on the original towers it may be deemed desirable to establish a second steam-electric central station which would feed the system at another point, thus economising in line conductors and rendering additional reliability

The production of energy from a fifty thousand kilowatt station properly designed approaches an optimum of economy of cost per kilowatt hour A larger station would reduce these costs but little except that advances in the engineering science of steam production and of heat balance might make reduction possible The economy of a station newly designed and constructed of from 25,000 Kw to 50,000 Kw will be much beyond that possible in any of the present city stations which, like Topsy, "just growed"

Only one skilled staff will be required at a central station The best qualified available engineering and laboratory supervision can be utilised and the cost of such supervision becomes a negligible item in cents per thousand kilowatt hours

The provision of spare standby steam boilers and auxiliaries and of spare turbo-generators in *each* present city station, of a dimension *always to be kept proportionate to the load demand* will be unnecessary with a minimum of boilers and of generators in the central station only such spare capacity need be maintained as will permit taking one unit of capacity out of service for repair

The considerable expense for conduits, pumps intakes, cooling ponds etc, essential to scattered generating plants is concentrated into one less expensive provision for the same generating capacity at a central station, the same advantage prevails regarding buildings, fuel storage trackage fuel handling equipment, bunkers, ash handling devices and machine shop facilities

Temporarily until their useful life period shall have expired, the larger and newer boiler and generating units in Moose Jaw, Saskatoon and Regina should be utilised but only to a portion of their capacity as peak load carriers and may be kept under steam during winter months as emergency units, particularly during the period of single circuit transmission

1930 Conditions Which Would Obtain from Central Steam Station at Any Site Chosen

This would be operated to capacity except during autumn and winter peaks (Unless Saskatoon station be built) Regina would carry peak loads to 5,000 Kw, Saskatoon to additional 4,500 Kw, chiefly as a line regulator, otherwise the second 5,000 Kw unit at Regina would be used, or the new 5,000 Kw unit at Moose Jaw.

At anything over 2,000 Kw the two larger Regina units will consume about eleven pounds and fourteen pounds of steam per kilowatt hour respectively, the Moose Jaw new unit about 10.5 pounds, and the latest and largest Saskatoon unit about fifteen pounds.

Table No. 9.

STEAM CONSUMPTIONS OF TURBO-GENERATOR UNITS AVAILABLE AS PEAK LOAD CARRIERS.

At Regina·

No. 5. G E. 5,000 Kw , 3,600 Rpm , on 200lb Steam @ 700° F with 1.5" B.P (1925)
3,800lb plus 9.5lb/Kwh.

At 5,000 Kw	53,300lb	— 10 66 lbs. per Kwh	
4,000 Kw	— 41,800	- 10 45 lbs per Kwh.	
3,000 Kw	32,300	— 10 77 lbs per Kwh.	
2,000 Kw	— 13,300	- 13 30 lbs. per Kwh.	

No. 4. G E. 5,000 Kw , 3,600 Rpm., on 200lb @ 550° F with 2" B.P (1920)
5,000lb plus 12.65lb/Kwh

At 5,000 Kw	— 68,250lb	— 13 65 lbs per Kwh
4,000 Kw	55,600	13.90 lbs. per Kwh.
3,000 Kw	— 42 950	— 14 32 lbs. per Kwh
2,000 Kw	— 30,300	15 15 lbs. per Kwh
1,000 Kw	— 17,650	— 17 65 lbs. per Kwh

No. 3. Siemens 3,000 Kw , 3,600 Rpm on 200lb @ 550° F with 2" B P. (1915)
4,000lb plus 15lb/Kwh.

At 4,000 Kw	64,000lb	- 16 00 lbs. per Kwh.
3,000 Kw	— 49,000	— 16 33 lbs. per Kwh
2.000 Kw	34,000	17 00 lbs. per Kwh
1,000 Kw	— 19,000	— 19 00 lbs per Kwh

No. 2. Siemens 1,500 Kw
No. 1 Siemens 1,500 Kw

At Moose Jaw.

No 1 Parsons 5,000 Kw., 3,600 Rpm., on 250lb Steam @ 700° F with 1" B.P (1927)

At 6,250 Kw	10 15 lbs. per Kwh.
5,000 Kw	— 9 90 lbs. per Kwh.
3,750 Kw	— 10 34 lbs. per Kwh.
2,500 Kw	11 15 lbs. per Kwh.

No 2. G. E. 3,500 Kw , 3,600 Rpm on 160lb Steam @ 475° F with 1" B.P

At 3,500 Kw	14 20 lbs. per Kwh.
2,575 Kw	— 13 .60 lbs per Kwh
1,750 Kw.	14 .25 lbs per Kwh.

No 3. G. E. 1,000 Kw.
No. 4 1,500 Kw

At Saskatoon

No. 1 5,000 Kw Generator
No. 2 4,800 Kw
No 3, 2,500 Kw

At 5,000 Kw	— 14 95 lbs	At 4,800 Kw	17 5 lbs	At 2,500 Kw	— 16 9 lbs.
4,000 Kw	14 50 lbs.	4,000 Kw	— 17 1 lbs.	2,000 Kw	— 17 1 lbs.
3,750 Kw	14 55 lbs.	3,200 Kw	16 5 lbs.	1,500 Kw	18 2 lbs.
2,500 Kw	— 15 55 lbs.	2,400 Kw	— 17 7 lbs.	1,000 Kw	— 20 55 lbs.
1,250 Kw	— 19 70 lbs.	1,600 Kw	19 9 lbs.		

As emergency protection it would be wise to keep one unit in each city station along with its boiler bank under standby conditions, especially until the second transmission circuit be strung.

When any of these city generators are operated as condensers for voltage regulation it will be necessary to supply cooling steam to the turbine, which condition will facilitate the prompt use of any such unit for load carrying at any hour.

If the site of the central steam station be at *Roche Percee* the largest unit at the Saskatoon station will be more effective as a condenser than one at either Moose Jaw or Regina, that at Moose Jaw will be second choice for voltage regulation purposes.

If the site of the central steam station be at *Lake-of-the-Rivers* or at Elbow, the larger Regina units along with that at Saskatoon, would be most effective as condensers, though neither would be immediately essential for such purpose.

The use of generating equipment at Saskatoon or at Regina would thus be more likely to be demanded (1) as peak load carriers during autumn and winter, (2) as emergency protection to ensure continuity of service at these relatively outlying cities.

The larger units at Regina and at Moose Jaw can be operated at least cost as emergency and as load carrying generators. These would be called upon each winter until the gross demand upon the system become so great that the capacity at the central steam station must be enlarged. A second transmission circuit would then be strung and the need for use of the city generating units as emergency sources of supply would diminish or disappear, later on the winter peaks of demand would again require their operation. By that date the use of these units would be strictly limited to the function of peak carrying for short hours daily.

On account of its greater economy the central station principle would be expanded, always in anticipation of the load growth, and the relative value of the local units would lessen, their period of useful life would draw to a close, and eventually local synchronous motor condenser units specially designed for purposes of voltage regulation would be installed at one or two selected points upon the transmission system. These would cost not over $6.00 per kilovolt-ampere of capacity if installed in present city power house building.

Effect on Energy Costs Caused by Operation of City Generators During Peak Loads

During the period prior to the installation of a second high-tension transmission circuit the local units at Moose Jaw and (or) Regina (assuming Saskatoon not to have built its new station in the interim), would be maintained ready to serve throughout the year as emergency local and system supply. This would continue from the initiation of central supply until growth of load requires enlargement of the central supply, *e.g.*, its increase in capacity from 25,000 kilowatts to 50,000 kilowatts about 1934 or 1935.

The standby charges would cover the maintenance of one or more boilers under steam, and the daily warming up of one turbine; the service charges would cover the operation of one—or more—turbo-generators under load daily during the winter for a few hours The total number of kilowatt hours to be produced by the local unit during a year would be small compared with the total number absorbed by the entire system, while the unit cost of these kilowatt hours would be high, the gross addition of the standby and generating costs at the local station would be very moderate in comparison with the total costs of all the energy to be supplied to the system.

In the subjoined typical study the costs have been viewed in this form in order to determine the average cost of all kilowatt hours generated While the "standby" costs (as contrasted with the "producing" costs by the operation of the local unit), might be considered properly chargeable to the energy delivered in the city in which the unit is operated, they are not so segregated in this study, being charged against the system as a whole since by such operations the immediate expense of a second transmission circuit is avoided.

Table No. 10.

ESTIMATE OF YEARLY COSTS OF KEEPING BOILERS UNDER STEAM FOR EMERGENCY PROTECTION ONLY PER CITY STATION AS UTILISED

Wages	$7,500 00	
Fuel	7,000 00	
Water	100 00	
Stores, etc.	400 00	
Maintenance	1,500 00	
Superintendence (chargeable)	500 00	
		$17,000 00

ESTIMATE OF YEARLY COSTS OF OPERATION OF LOCAL BOILERS AND TURBO GENERATORS DAILY FROM NOVEMBER 1ST TO APRIL 1ST TO CARRY PEAK LOADS OF DEMAND UPON THE SYSTEM (ADDITIONAL TO THAT FOR EMERGENCY SERVICE)

Wages (@ 75 00/day 200 days)	$15,000 00
Water	500 00
Oil and Waste, Stores, etc (7.50/day).	1,500 00
Maintenance, Wages and Material	10,000 00
Superintendence (chargeable).	3,000 00
	$30,000 00
Fuel—per 1,000,000 Kwh. under these conditions.	$ 7,000 00

or 9c per Kwh.

Electric Loads

Table No. 11 hereto attached sets out the 1926 peaks of electric power demand on each city, town and village along the lines of

transmission studied, as far as these details have been reported to your Commission These lines are in the order listed in the table:

Roche Percee to Regina.
Regina to Moose Jaw
Moose Jaw to Saskatoon.
Saskatoon to Prince Albert.
Regina to Kamsack.
Saskatoon to The Battlefords.

Estimates of the 1930 and 1935 "Peaks of Demand" which would be drawn from transmission lines connecting all these points are also set out, increase of demand being computed on the basis of an annual rate of 10 per cent

Table No. 11.

ESTIMATES OF PEAK DEMANDS AND OF KILOWATT-HOUR CONSUMPTIONS ON CONSIDERED TRANSMISSION SYSTEMS AS OF 1930 AND 1935.

Towns	1926 Population	K W Demand			Yearly Load Factor			Kilowatt-Hour Consumption		
		1926	1930	1935	1926	1930	1935	1926	1930	1935
Mines			1,000	1,600					1,200,000	1,800,000
Roche Percee	60		5	8		114	20		5,000	14,000
Estevan	2,519	289	424	682	277	300	35	702,888	1,110,000	2,090,000
Macoun	176		11	18		114	.20		11,000	32,000
Midale	160		10	16		114	.20		10,000	29,000
Halbrite	126		8	13		114	20		8,000	23,000
Weyburn	4,000	335	565	910	.306	320	.35	1,034,206	1,590,000	2,790,000
McTaggart	70		5	8		114	.20		5,000	14,000
Yellowgrass	490	86	58	85	141	200	.25	44,600	93,000	186,000
Ibsen										
Lang	341	24	35	56	100	200	.25	21,000	61,000	122,000
Milestone	485		40	65		200	25		70,000	142,000
Regina	37,875	8,000	11,720	18,850	350	370	40	24,523,155	38,900,000	66,200,000
Totals	46,252		13,876	22,211					42,063,000	73,442,000
Pense	266		16	26		.200	.20		28,000	46,000
Belle Plaine	54		4	7		114	.20		4,000	11,000
Moose Jaw	21,213	3,925	5,750	9,260	372	.372	40	12,752,312	18,700,000	32,400,000
Totals	21,623		5,770	9,293					18,732,000	32,457,000
Tuxford	142	7	10	16		114	20		10,000	29,000
Chamberlain	120		8	13		114	20		8,000	23,000
Aylesbury	126		8	13		114	.20		8,000	23,000
Craik	627	23	34	55	109	.200	.25	22,000	60,000	120,000
Girvin	117		7	11		114	20		7,000	20,000
Davidson	657	45	66	106	260	.300	.30	102,263	173,000	278,000
Bladworth	211		13	21		114	20		13,000	37,000
Kenaston	286		14	23		114	20		14,000	40,000
Hanley	343		21	34		200	25		37,000	75,000
Dundurn	216		13	21		114	20		13,000	37,000
Saskatoon	28,312	6,100	8,950	14,300	360	370	40	10,256,980	29,000,000	50,200,000
Totals	31,107		9,144	14,613					29,343,000	50,882,000

Towns	1926 Population	K W Demand			Yearly Load Factor			Kilowatt-Hour Consumption		
		1926	1930	1935	1926	1930	1935	.926	1930	1935
Warman	175		11	18		114	20		11,000	32,000
Hague,	273		17	27		114	20		17,000	47,000
Rosthern	1,181		90	145		200	25		157,000	327,000
Duck Lake	481	7	35	56	083	200	25	5,100	61,000	123,000
Prince Albert	7,.00	900	1,320	2,120	403	400	40	3,174,733	4,650,000	7,430,000
Totals	9,210		1,473	2,386					4,870,000	7,959,000
Balgonie	224		10	16	086	114	20	7,509	10,000	28,000
Qu'Appelle	725	32	47	75	.00	200	25	28,000	82,000	164,000
Indian Head	1,583	93	136	219	193	250	30	156,580	298,000	575,000
Fort Qu'Appelle	435		27	44		114	20		27,000	77,000
Balcarres	458	24	35	56	096	200	.25	20,100	61,000	123,000
Duff	122		8	13		114	20		8,000	23,000
Melville	3,089	100	235	378	217	250	30	304,950	514,000	993,000
Yorkton	5,666	305	447	720	.314	325	.35	338,736	1,272,000	2,210,000
Canora	1,359		200	322		300	.35		525,000	987,000
Kamsack	2,075	175	257	414	322	.325	.35	494,199	732,000	1,267,000
Totals	15,676		1,402	2,257					3,529,000	6,447,000
Dalmeny	145		9	14		114	20		9,000	24,000
Langham	430	19 3	28	46	146	200	25	24,651	49,000	98,000
Borden	176		11	18		114	20		11,000	31,000
Radisson	431	23 4	34	55	120	200	25	24,550	60,000	120,000
Fielding	110		7	11		114	20		7,000	19,000
Maymont	166		10	16		114	20		10,000	28,000
Ruddell	110		7	11		114	20		7,000	19,000
Denholm	120		8	13		114	20		8,000	23,000
Battlefords	5,450	610	893	1,435	236	.250	30	1,260,814	1,950,000	3,770,000
Totals	7,138		1,007	1,618					2,111,000	4,132,000

Records of the rates of *average* hourly energy consumption rate to the *maximum* rate during 1926 are listed as "*Load Factor*" (on present steam electric plants) In common with all American and Canadian experience the load factor tends to increase as full use of domestic power develops Estimates of the probable 1930 and 1935 load factors at each point of delivery are listed and also estimates of the quantity of energy required at each city and town

It will be noted that the influence of the principal centre of population in each group is all-important that the requirements of Regina, Moose Jaw and Saskatoon far outweigh all other, the requirements of all three outlying branch lines combined being less than the needs of Moose Jaw alone Not only is this true with regard to the kilowatts of peak demand but also with regard to the kilowatt hours required The consumption of energy *per head* of population in the cities is far greater than in the small towns and villages (See Tables Nos 4, 8 and 9 above

In Table No. 12. Sheet "A" are set out the 1930 and 1935 conditions which would appear on transmission systems if fed from a central station at Roche Percee, it has been assumed that certain farm power shall be delivered along the lines For the three major cities only line "A 3" shows the needs beyond Moose Jaw to Saskatoon, line "A 7" the cumulation beyond Regina, and line "A 8" the cumulated needs for all three cities It will be noted that the 1930 peak of demand is greater than 25 000 Kw, a portion of the peak could be carried by city generators, of which the larger and newer units only can yield 20 000 Kw similarly for 1931, additional central generating station capacity would be required in 1932 or 1933 depending upon the actual growth of joint service demands.

On the same sheet, cumulations are shown as for the three cities plus the Yorkton-Kamsack Branch from Regina

In Table No 12, Sheet "B" are set out the 1930 and 1935 estimated demands and consumptions "B 3" toward Saskatoon, "B 5" toward Regina "B 7" cumulative from Lake-of the-Rivers central station site to serve all three cities only Lines "B 11," "B 12" and "B 13" show the peaks and the quantities of energy to be carried over transmissions from that central station the load peaks only being carried by present city generators Lines "B 14," "B 15" and "B 16" show the same factors if branch transmission lines beyond Saskatoon and Regina be included within the high tension distribution system

In Table No 12, Sheet "C" are set out the similar peaks of demand and quantities of energy to be delivered from a central station site at Elbow The table is self-explanatory It will be seen that the "Branch" lines add relatively small proportions to the total requirements of the cities.

On the assumption that the Electric Transmission System be ready for service in 1930 the following bases of estimated kilowatt demands and of kilowatt-hour consumption have been prepared.

Details for each small town are not here itemised as being too uncertain, but as to the sections of the transmission system listed the story should be approximately correct.

Basing on the 1926 figures where electric service is now available, assuming a 10 per cent. per annum increase in peak demand (1926 x 1.464 for 1930, 1926 x 2.257 for 1935, and for a slight increase in load factor to be anticipated with the extension of the service, and the more common use of electric utensils, allocating a reasonable utilisation of energy to population centres not now served after assuming 5 per cent. annual growth of population in these smaller places:

There has been developed Table No. 12 which is applicable to supply of energy from (A) Roche Percee, (B) Lake-of-the-Rivers, (C) Elbow.

(Population growth—4 years 1.22, 9 years 1.55 x 1926.)

Table No 12
Sheet "A"

From 25,000 Kw Steam-Electric Station at Roche Percee to Cities, Towns, Villages and Farms

Section units	1926 Population	1930 Sum of Kw peaks	1930 Load factor	1930 Kwh	1935 Sum of Kw peaks	1935 L.F average	1935 Kwh. consumption	1935 Kwh per head
A.1 To Regina	46,252	13,876	0.348	42,163,000	22,211	0.379	73,442,000	1,018
A.2 Regina-Moose Jaw	21,533	5,770	0.371	18,732,000	9,293	0.398	32,457,000	1,000
A.3 Moose Jaw-Saskatoon	31,107	9,144	0.367	29,343,000	14,6.3	0.397	50,882,000	1,060
A.4 Regina-Kamsack	15,676	1,402	0.289	3,529,000	2,257	0.331	6,447,000	265
A.5 Saskatoon-Battleford	7,128	1,007	0.240	2,111,000	1,618	0.292	4,132,000	872
A.6 Saskatoon-Prince Albert	9,210	1,473	0.381	4,896,000	2,366	0.385	7,959,000	594
Adjusted for Possible Farm Loads								
A.1	47,500	14,000	0.347	42,400,000	22,500	0.374	74,000,000	1,001
A.2	22,000	6,000	0.363	19,000,000	9,600	0.394	33,000,000	970
A.3	32,500	9,300	0.363	29,500,000	15,000	0.392	51,400,000	1,002
A.4	17,000	1,700	0.262	3,900,000	2,700	0.296	7,000,000	265
A.5	8,000	1,200	0.228	2,400,000	1,900	0.277	4,600,000	371
A.6	10,000	1,600	0.365	5,100,000	2,600	0.370	8,400,000	540
Cumulative to *Three Principal Cities* only								
A.7 Regina-Moose Jaw	52,840	15,300	0.362	48,500,000	24,600	0.392	84,400,000	
A.8 Roche Percee-Regina	98,892	29,300	0.356	90,900,000	47,100	0.383	158,400,000	
Reduced by Winter Peak Supplied from Regina, Moose Jaw and Saskatoon (20,000 Kw max.)								
A.9 Regina-Moose Jaw		15,300	0.362	48,500,000	14,600	0.627	80,000,000	
A.10 Roche Percee-Regina		25,000	0.410	90,000,000	*27,100	0.585	140,000,000	

*This is greater than the capacity of the Roche Percee 25,000 Kw Station

Cumulative as A 10 but Adding Kamsack Branch

A 11 Roche Percee-Regina	25,000		98,900,000	29,800*	0.656	145,000,000

*This is greater than the capacity of the Roche Percee 25,000 Kw Station

Cumulative as Above A 11 but Adding Prince Albert and Battleford Branches

A 12 Moose Jaw to Saskatoon	12,100	0.350	37,000,000	14,500	0.457	58,000,000
A 13 Regina to Moose Jaw	18,100	0.358	56,000,000	19,100	0.490	87,000,000
A 14 Roche Percee to Regina	25,000	0.455	99,800,000	34,300	0.437	145,000,000

Table No 12
Sheet "B"

SUPPLY FROM CENTRAL STEAM-ELECTRIC STATION AT LAKE-OF-THE-RIVERS (25,000—50,000 Kw)

Section units	1930 Kw	1930 Load Factor	1930 Kwh	1935 Kw	1935 Load Factor	1935 Kwh
B. 1 Saskatoon to Prince Albert	1,600	0.364	5,100,000	2,600	0.369	8,400,000
B. 2 Saskatoon to Battlefords	1,200	0.228	2,400,000	1,900	0.277	4,600,000
B. 3 Moose Jaw to Saskatoon	9,300	0.363	29,500,000	15,000	0.391	51,400,000
B. 4 Regina to Kamsack	1,700	0.262	3,900,000	2,700	0.295	7,000,000
B. 5 Moose Jaw to Regina	12,000	0.365	38,300,000	19,200	0.397	66,800,000
B. 6 Lake-of-Rivers to Moose Jaw	5,800	0.371	18,800,000	9,400	0.412	32,600,000
Cumulative to Three Cities— Regina, Moose Jaw, Saskatoon—only						
B. 7 Lake-of-Rivers to Moose Jaw	27,100	0.363	86,600,000	43,600		150,800,000
Cumulative Including Branches If Entire Supply from Central Steam-Electric Station						
B. 8 Moose Jaw to Saskatoon	12,100	0.349	37,000,000	19,500	0.377	64,400,000
B. 9 Moose Jaw to Regina	13,700	0.351	42,200,000	21,900	0.387	73,800,000
B.10 Lake-of-Rivers to Moose Jaw	31,600	0.356	98,000,000	50,800	0.385	170,800,000
Cumulative to Three Cities Only—Peaks Carried by Present City Stations						
B.11 Moose Jaw to Saskatoon (Saskatoon 1,300/3,000)	8,000	0.417	29,200,000	12,000	0.482	50,600,000
B.12 Moose Jaw to Regina (Regina 3,000/4,200)	9,000	0.474	37,400,000	15,000	0.500	65,600,000
B.13 Lake-of-Rivers to Moose Jaw (Moose Jaw 0/3,400)	22,800	0.430	85,400,000	33,000	0.513	147,900,000
Cumulative to Cities and All Branches—Peaks Only Carried by City Units.						
B.14 Moose Jaw to Saskatoon.	10,800	0.387	36,700,000	16,500	0.467	63,600,000
B.15 Moose Jaw to Regina	10,700	0.443	41,800,000	17,700	0.470	72,600,000
B.16 Lake-of-Rivers to Moose Jaw	27,300	0.404	96,800,000	40,200	0.448	166,900,000

NOTE.—Saskatoon carrying 1,300 Kw peak in 1930, 3,000 Kw in 1935.
Regina carrying 3,000 Kw peak in 1930, 4,200 Kw in 1935.
Moose Jaw carrying none in 1930; 3,400 Kw in 1935.

Table No 12
Sheet "C"

SUPPLY FROM CENTRAL STEAM-ELECTRIC STATION AT ELBOW (25,000—50,000 Kw)

Section units	1930 Kw	1930 Load Factor	1930 Kwh	1935 Kw	1935 Load Factor	1935 Kwh
C 1 Saskatoon to Prince Albert	1,600	0.365	5,100,000	2,600	0.370	8,400,000
C 2 Saskatoon to Battlefords	1,200	0.228	2,400,000	1,900	0.277	4,600,000
C 3 Elbow to Saskatoon	9,100	0.368	29,300,000	14,700	0.396	51,000,000
C 4 Elbow to Moose Jaw	5,900	0.366	18,900,000	9,500	0.394	32,800,000
C 5 Moose Jaw to Regina	12,000	0.365	38,300,000	19,200	0.399	66,800,000
C 6 Regina to Kamsack	1,700	0.262	3,900,000	2,700	0.296	7,000,000
Cumulative to Three Principal Cities Only						
C 7 Elbow to Moose Jaw	17,900	0.365	57,200,000	28,700	0.396	99,600,000
C 8 Total Elbow Output	27,000	0.366	86,500,000	43,400	0.396	150,600,000
Cumulative Including All Branches						
C 9 Elbow to Saskatoon	11,900	0.352	36,600,000	19,200	0.382	64,000,000
C.10 Moose Jaw to Regina	13,700	0.351	42,200,000	21,900	0.385	73,800,000
C 11 Elbow to Moose Jaw	19,600	0.356	61,100,000	31,400	0.387	106,600,000
C.12 Total Elbow Output	31,500	0.355	97,000,000	50,600	0.385	170,600,000
Cumulative to Three Cities Only Peaks Carried on Three City Plants						
C 13 Moose Jaw to Regina (3,000/4,200)	9,000	0.474	37,400,000	15,000	0.507	65,600,000
C.14 Elbow to Moose Jaw (0/3,400)	14,990	0.431	56,300,000	21,100	0.530	97,500,000
C.15 Elbow to Saskatoon (1,300/3,000)	7,800	0.425	29,000,000	11,700	0.490	50,200,000
C 16 Total Elbow Output	22,700	0.428	85,300,000	32,800	0.514	147,700,000
Cumulative to Cities and All Branches- Peaks Carried on Three City Plants.						
C 17 Elbow to Saskatoon	10,600	0.393	36,500,000	16,200	0.446	63,200,000
C.18 Moose Jaw to Regina	10,700	0.441	41,300,000	17,700	0.468	72,600,000
C.19 Elbow to Moose Jaw	16,600	0.414	60,200,000	23,800	0.502	104,700,000
C.20 Total Elbow Output	27,200	0.406	96,700,000	40,000	0.479	167,700,000

NOTE.—Regina carrying 3,000 Kw peak in 1930, 4,200 Kw in 1935.
Saskatoon carrying 1,300 Kw peak in 1930, 3,000 Kw in 1935.
Moose Jaw carrying none in 1930, 3,400 Kw in 1935.

In Table No 13 is set out an estimate of the populations probable along each section of the transmission system along with a computation of the probable average energy requirements per head.

Table No 13

POPULATION ON AND NEAR TRANSMISSION LINES AT INCREASE OF FIVE PER CENT PER ANNUM

Year	Roche Percee to Regina	Regina to Moose Jaw	Regina to Kamsack	Moose Jaw to Saskatoon	Saskatoon to Battle-fords	Saskatoon to Prince Albert
1926	46,252	21,533	15,876	31,107	7,138	9,210
1930.	56,400	24,000	16,750	34,600	7,960	10,250
1935	72,000	32,300	24,300	48,000	11,100	14,600
	Adjusted for Farm Dwellers. *(Estimated at 10 Persons Per Mile, Approximately)*					
1926	47,500	22,000	17,000	32,500	8,000	10,000
1930	57,600	26,700	20,600	39,400	9,700	12,120
1935	73,700	34,100	26,400	50,400	12,400	15,500
	Kwh Per Head					
1930	750	781	165	850	266	476
1935.	1,018	1,000	265	1,060	372	594
	Kwh Per Head Adjusted to Farm Loads.					
1930.	735	712	187	750	247	420
1935	1,001	970	265	1,002	37.	540

The exact quantities of energy to be supplied by each present city station during the early history of any joint system would be subject to the instructions of the system load despatcher They would be relatively small because the energy from the central station would be cheaper

Estimate of Kilowatt-Hour Production at *Moose Jaw* by use of one 5,000 Kw unit and at *Regina* of two 5,000 Kw units as Peak Load Carriers.

1930 (1) If No Transmission Beyond Saskatoon

Gross Peak west of Regina, 15,300 Kw ,

North of Roche Percee, 29,300 Kw

It is evident that the Moose Jaw unit will *not necessarily* be so operated since the Roche Percee 25,000 Kw station—by the aid of one 5,000 Kw unit at Regina—can carry the Moose Jaw and Saskatoon joint peaks.

The Moose Jaw unit (or a Saskatoon unit) may be operated as a condenser only, if at all

(2) *If Transmission be Extended to Prince Albert and to the Battlefords*

Gross Peak west of Moose Jaw, 18,100 Kw ,

North of Roche Percee, 32,100 Kw

The Moose Jaw unit need not be operated, since the capacity of the Roche Percee station, in conjunction with the two 5,000 Kw units at Regina can still carry the load

For voltage regulating purposes it would be better to operate a unit at Saskatoon even though the cost of kilowatt hours there generated (with the present equipment) would be greater than if the Moose Jaw unit were to be used

(3) *If Transmission be Extended to Kamsack*

Gross Peak west of Moose Jaw as before, 18,100 Kw ;

North of Roche Percee, 33,800 Kw

The two Regina units in conjunction with the equipment of the Roche Percee station could still carry those peaks, one 5,000 Kw unit there along with the 5,000 Kw generator at Moose Jaw would serve.

As stated elsewhere, since the possible capacity of the Roche Percee station without considerable water storage is limited by the available quantity of condenser water supply which can be developed by local pondage, the estimates in this report are based upon a 25,000 Kw construction there Its sufficiency for a few years depends upon the extent of branch transmission lines constructed

1935—(1) *No Transmission Beyond Saskatoon.*

Gross Peak west of Regina, 24,600 Kw ,

North of Roche Percee, 47,100 Kw

It appears that the operation of the Moose Jaw unit will be necessary daily throughout all winter peak hours.

(2) *Transmission to Prince Albert, to the Battlefords, and to Kamsack*

Gross Peak west of Regina, 29,100 Kw ,

North of Roche Percee, 54,300 Kw

The larger present units in all three cities could carry

Moose Jaw	5,000 Kw	
Saskatoon	5,000 Kw	
Regina	10,000 Kw	
		20,000 Kw

The only important additional emergency units available would be

At Moose Jaw	3,500 Kw	
At Saskatoon	4,000 Kw	
At Regina	3,000 Kw	
		10,500 Kw

Ostensibly the 1935 gross peak of 54,300 Kw could be provided from all these units in combination with the 25,000 Kw capacity at Roche Percee

Practically it would be extremely unwise to depend upon this arrangement. Before 1935 additional central steam station capacity should be provided, of at least 25,000 Kw This capacity should not be at Roche Percee unless considerable water storages be made available and are constructed, but at Lake-of-the-Rivers or at Elbow where is to be had plenty of condensing water.

SUMMARY.

From Steam-Electric Generating Station at Roche Percee

Gross Demands by Transmission System

	To Regina, Moose Jaw and Saskatoon only		Same plus branches to Kamsack, Prince Albert and Battlefords	
	1930	1935	1930	1935
Kilowatts				
Peak Demand	29,300	47,100	33,800	54,300
Kilowatt hours,				
Total Requirements.	90,900,000	158,400,000	102,300,000	178,400,000

Assuming that one 5,000 Kw unit at Regina be used for five months during the winter of 1930-31, carrying a four hour peak of 4,000 to 4 500 Kw daily for six days per week, it would deliver into the system about 900,000 Kwh during the winter

If two such units be used that year as for the larger system demand the delivery would total approximately 2,500,000 Kwh

The supply from Roche Percee would be
For Regina, Moose Jaw and Saskatoon 90,000,000 Kwh
For the larger system (with branches) 99,800 000 Kwh

The annual load factor on the Roche Percee station would thus be 41 per cent. for the smaller scheme, or 45 per cent for the larger

NOTE.—In preparing table from Roche Percee for 1930, Regina units only are assumed in use, two for the larger scheme, and one for the three cities only

For 1935

The Saskatoon larger unit is assumed working on 15 per cent. l f annually 6,400,000 Kwh

The Moose Jaw unit is assumed on 20 per cent l f 9,000,000 Kwh

And the Regina two units on 20 per cent. l f annually 17,000,000 Kwh

The various cumulative figures in Table No 12 show that the transmission circuit will not be loaded to capacity all the hours of the year, the percentage of peak demands thereon is noted in each case as the *Line Load Factor*

Tables No. 12 B and No. 12 C covering supply from Lake-of-the-Rivers or Elbow respectively are developed on the assumption that the city units be used as peak load carriers only, and be not called upon to deliver any large proportion of the total energy requirements of the system. These units would be used more freely during the year or two just prior to the enlargement of the capacity of the central station, but the figures are not given, they would closely resemble the figures set out for the Roche Percee station. It will be noted that in Tables No. 12 B and 12 C the central station, either at Lake of the Rivers or at Elbow, is credited with a larger number of kilowatt hours than in Table No. 12 A is the Roche Percee station credited, and this in spite of the fact that no supply from Lake-of-the-Rivers or Elbow is proposed for Weyburn or Estevan nor for any point south of Regina.

The Transmission System

From the *Roche Percee* station of 25,000 Kw. capacity this will comprise a line of single circuit steel towers to Regina (or double circuit if condensing water can be assumed at Roche Percee) and double circuit towers bearing at first a single circuit, from Regina to Moose Jaw and to Saskatoon. The branches to Prince Albert and to the Battlefords from Saskatoon and to Kamsack from Regina will be of single circuit towers or wood pole lines.

From a *Lake-of-the-Rivers* station to Moose Jaw, Regina and Saskatoon there would be a line of double circuit towers bearing at first a single circuit. From an *Elbow* station there would be double circuit towers to Regina via Moose Jaw and to Saskatoon.

The energy would be transmitted to the principal cities at approximately 110,000 volts between conductors. This pressure is recommended from considerations of economy, distances involved, the distribution of load centres, and the relative market availability of moderate sized transformers to serve groups of the smaller villages and farms, equipment is standardised in America for this voltage. Although the maximum distance for power transmission under study might seem to warrant a higher pressure, such is not advised for the initial system.

For the branch circuits beyond those cities pressure of 38,000–66,000 volts has been chosen in view of the relatively small loads to be transmitted. These circuits are of capacity (5,000 Kw.) being considerably larger than necessary for the 1935 loads. Small villages and towns lie along railways at intervals of from six to nine miles. From the *branch* transmission lines each village can be served direct by reason of the lower voltage of transmission. For groups of small villages passed by the 110,000 volt circuits a secondary transmission system of 13,200 volts would be selected, affording opportunity for economical distribution to farm settlements or to individual farmers. Craik, Girvin, Davidson and Bladsworth would form such a group—to be fed from a secondary distribution.

It will be observed that the single circuit from Roche Percee would not be duplicated unless the station be enlarged, a program

of doubtful economy because of the expense for storages of Souris River waters above referred to. The line from Elbow or from Lake-of-the-Rivers can and will be duplicated, and properly so, as the system grows. Demands beyond the capacity of these *two* circuits would be met by installation of a second tower line from whatever site be chosen for the enlargement of the central station supply beyond 50,000 kilowatts.

Diagrams "A.1," "B.1," "B.2," "C.1," and "C.2" are attached showing to scale the transmission systems studied with respect to each of the three central sites under consideration. These are self-explanatory in relation to Table No. 12. On the map of Central Saskatchewan are indicated the routes for these optional transmission systems.

It will be noted that the principal cities, with their loads much more important individually and cumulatively are much more distant from a steam station at Roche Percee than from either of the other sites studied at Lake-of-the-Rivers and at Elbow. The latter sites are relatively near the centre of gravity of the whole system, this fact is reflected in the estimates of the total costs of the power schemes and in the relative costs of the kilowatt-hours delivered at the principal cities.

Steam-Electric Generating Station

For all three alternative sites a net installed capacity of 25,000 Kw. is contemplated for the initial installation and installed in all respects as an integral unit. Future extension would be added also as a unit but connected with the first to a common switch board, and also to the steam header and to the coal distribution layout of the first.

The 25,000 Kw. unit would consist of two 12,500 Kw. main turbo-alternators and one 1,000 Kw. non-condensing house unit to take care of station auxiliaries which, with boiler pump, would be motor driven.

The boiler plant would consist of four boilers, each of 1,200 rated H.P., which, assuming one to be a spare unit, would carry the peak load at about 300 per cent rating. Boiler pressure would be 350 to 360 pounds gauge and 725° total steam temperature. They would be of modern design with water-cooled walls and preheaters and arranged in pairs delivering flue gases to common stub stacks supported on the building steel. Each boiler would have its own induced draft fan system and a forced draft system depending on the method of firing. The accompanying sketch (Plan 2) shows a central or storage system of pulverised firing, but the actual system to be chosen, whether by alternative of unit system or mechanical stokers, should be left for future decision. The differences in capital cost among all three would be so small as to have little bearing on the station charges when all the relative features are considered.

The station heat consumption would be from 18,000 to 18,500 B T U per net Kwh output depending on the design, which would be governed by the price and quality of the basic fuel used

The main generating units would be of a standard type at 1,800 R P M with direct connected exciter and delivering three-phase, 60 cycles and 13,200 volts. Steam inlet conditions would be 320-325 lbs. gauge and 725° temperature Each would have a standard type of surface condenser which based on 60° cooling water would provide a back pressure of 1½ inches absolute They would operate on a modified regeneration cycle bleeding at two points below atmosphere and possibly a third point above atmosphere and possibly a third point above atmosphere to non-contact heaters in the condensate and feed circuits.

The house unit would be of a rugged type at 3,600 R P M with inlet steam conditions as above and exhausting into a standard type of open deærating heater at 0 to 2 lbs gauge pressure. A by-pass from the exhaust would lead to a two-effect make-up evaporator with condenser in the main condensate circuit The unit would deliver three-phase, 60-cycle, and 2,300 volts with direct connected exciter

The auxiliary service would have its own separate wiring layout with throw-over switch and transformers to feed to or from the main bus depending on the auxiliary power demand and the heat balance requirements This would relieve the main bus as far as possible from disturbances due to starting the station motors and provide a reliable source of power during possible interruptions on the transmission line A suitable motor-generator set would supply direct current for battery charging and for direct current-driven auxiliaries.

The Condensing Water System would depend on the conditions at the site to be chosen In any case the plant would be as near as possible to the lake or river with an intake house with travelling screen and inlet and discharge conduits with provision for returning warm water as required to the intake to relieve ice conditions. The circulating pump layout would depend on the range of levels in the lake or river and would involve either vertical submerged pumps or pumps in a submerged pump pit. Full protection against scour and changes in river channel would be made

The accompanying estimates of capital and generating costs are based on the data available at the moment. The ultimate design should be based on an intimate study of the features of the site chosen, keeping in view the probable future loads and conditions. The possibility and probability of coal carbonisation should be noted and the boiler plant designed accordingly with a view to the possibility of using char The coal handling equipment should be laid out for ample storage to take care of traffic interruptions, and to keep down handling costs.

Power House Buildings

The building would be similar to that shown in the attached sketch (Plan D.) A complete structural steel framework to include crane columns would be encased in either brickwork or concrete walls, with insulated roof on concrete or gypsum slab windows of steel with integral storm sash Ventilation to be provided by swinging sash and wall louvres Steel supports for slabs, boilers, coal bins, etc, would be provided

A skeleton vacuum radiation system with radiators under the windows to prevent frosting and possibly a hot blast fan system to prevent condensation under the roof slabs would be necessary The turbine operating floor would consist of islands with railing around the machines to permit full view of the auxiliary operating floor in the basement below The boiler room would have a floor at heater and turbine elevation and ample stair connection to the boiler operating floor and steam headers The feed pumps and heaters evaporator etc, would be operated from the boiler room basement.

The annex would have two floors and basement, the last to contain battery room and machine shop and stores, and the other floors, offices, switchboard gallery laboratory stores etc.

Provision for future extension at the opposite end of both turbine and boiler rooms is contemplated Approximately ten operators' and staff cottages in the neighbourhood are provided for

The building estimates contemplate a very plain simple fireproof station building since none of the sites is such that costly architecture is justified

Full data are not available on foundations at any of the sites and an average quantity of piling is assumed for main building and intake and coal handling structures.

The water conditions at the *Roche Percee* site are particularly acute due to the frequency of low or negligible flow in the Souris River The accompanying curves show the flow covering a number of years A spray pond to provide for the low summer flows appears absolutely necessary and for a plant of 25,000 kw one of 350 feet square with 1,500 nozzles should be provided It is estimated that there would be a loss due to evaporation from the sprays alone of over one cubic foot per second, which in low flows would in itself and aside from seepage cause an appreciable drain on the pond

The flow of the Souris River is occasionally nil, for a period of over twenty-one months the average has fallen so low that the maximum passing Estevan was only three (3) second feet, and the average was only one and one sixth cubic feet per second

A graph (L") is attached to this report showing the mean monthly discharge of the Souris River near Estevan for the years 1913 to 1923 Since 1923 no records of flow have been kept by the Water Power Branch of the Department of the Interior, from whose files the information has been derived.

For a station exceeding 25,000 Kw very elaborate studies and surveys are essential to establish the feasibility of auxiliary storage of Spring floods in coulees upstream and of economical extension to the spray pondages. A visit to the southern states to study their practice in the meeting of comparable conditions is considered advisable in any case before this site is favourably decided upon. For several months of the year high condensing water temperatures, and therefore high steam consumption, must be expected.

Fuel would be derived from the mines operated in the Bienfait district, and would be delivered to the station over a standard gauge tramway built for the purpose, equipped with its own locomotives and rolling stock. This specially constructed tramway will be the most satisfactory means of gathering coal from the mines, assuring continuous service with the minimum of local storage. The cost of transferring coal by Canadian Pacific Railway via Estevan is quoted at one dollar per ton, including charges over railway branches south of Bienfait. The proposed tramway can deliver coal for slightly over half that cost, all charges of interest, maintenance and operation being included.

Estimates by mine owners show that coal from present mines can be delivered at the Roche Percee station for about two dollars and ten cents per ton, and on this estimate our studies of cost of energy are based. This corresponds to a cost for heat values of fifteen-and-a-half cents per million British Thermal Units ($0.155 per million B.T.U.)

The site tentatively chosen at the *Lake-of-the Rivers* is on a neck of land about 10,000 feet across and separating two arms of the lake. By taking cooling water from one arm and delivering it to the other, a circuit of seven miles is obtainable, or simpler arrangements may be possible. The lake itself is of sufficient size to take care of a station of any desirable capacity. The site could be connected to the Canadian National Railway at Mitchellton by a spur not over three miles long.

A seam of lignite outcrops at several points near the two northerly arms of the lake, and coal has been extracted on a small scale, but to no great commercial extent. Definite knowledge as to the extent and continuity of the field is lacking. It should be determined whether sufficient coal can be obtained for a station of fifty thousand kilowatts capacity for fifty years, for the reasonably estimated life period of the equipment. This would require about six square miles of mine workings on a seven foot seam. Only a considerable series of borings would prove the general thickness and the extent of the coal beds here.

Proximate analysis showed

Moisture	32.12%
Volatile	28.29%
Fixed Carbon	31.32%
Ash	7.97%

Calorific value—10,000 B.T.U. when moisture free.

(Department of Mines, July 13, 1912.)

As a supplement to the local supply, or as an alternative, Alberta fuels can be imported at reasonable costs. The estimates hereinunder presented consider a maximum cost for fuel based on the assumption that two-thirds be derived from local areas and one-third be drawn from Drumheller or from Crow's Nest mines. Taking local fuel at Two Dollars ($2.00), per ton, and imported fuel at quoted prices there appears a probable maximum cost for heat values of Eighteen Cents per million British Thermal Units ($0.18 per million B.T.U.).

At present it would seem unnecessary to forecast development of central steam-electric station capacity beyond 50,000 kilowatts. Complete studies based upon load and transmission developments would precede further central station constructions and the choice of location thereof

While full information as to the depths of the lake is lacking, we believe that it may be safely assumed that an ample supply of water for condenser purposes is at hand Certainly the surface area for cooling exists and it is only necessary to separate the intake and outlet of condenser conduits to ensure proper circulation. While the water is hard it does not contain in harmful quantity salts which would give difficulty in maintaining condenser piping. The analysis follows

Parts per million

Calcium carbonate	74
Magnesium carbonate	322
Magnesium bicarbonate	272
Sodium bicarbonate	608
Sodium sulphate	2,468
Sodium chloride	43
Total non-incrusting solids	3,117
Total magnesium and calcium carbonate	399

(W H Hastings, Engineer to Bureau of Labour and Industries, Saskatchewan, 1927)

The ultimate station capacity possible or desirable at this site cannot be definitely fixed It may prove that not over 50,000 kilowatts should be concentrated here, or the limit may be set at a much higher figure, dependent upon the results of exploration of the local coal supply, and upon the influence of the presence of that supply upon the prices for coals to be imported from Alberta. The site is relatively near to the centre of gravity of the present energy demand, and the economies of transmission therefrom cannot be greatly improved from any site adjacent to a proper and sufficient water supply The desire to feed a great mileage of high tension transmission system at more than one point thereon must have weight in the future If another site be chosen, it, too, should be relatively near the centre of gravity of the load on the system, or near the largest centre of that load unless the production and transmission costs should prohibit the freedom of choice.

For an output of 50,000 Kw this station would be equippe with five generator units of 12,500 Kw , one being spare, along with proper boilers and auxiliaries.

Fuel costs f.o.b. plant are assumed to be 15 cents per million B.T.U. from local and not over 24 cents for coal delivered from other fields.

The site tentatively chosen on the Saskatchewan River is near *Elbow* and the Elbow Indian Reserve. It is almost on a line joining Saskatoon and Moose Jaw and is distant 81 and 77 miles from those cities respectively. The advantages of such a site are

(1) Relative nearness to the centre of gravity of the power loads upon the limited "three city" system, as also of the enlarged layout including branches to Prince Albert, to the Battlefords and to the Kamsack area.

(2) The presence of an ample continuous supply of water for condenser purposes without pondage nor long conduits.

(3) The relative nearness to the Drumheller field whence large quantities of slack coals can be drawn, and in all probability, for a very long period of years. Other fuels from smaller fields, and even from The Crow's Nest area, are available at reasonable costs. Reference is here made to the table of fuel costs for the three sites appended to this report.

It is estimated that an ample assured fuel supply can be had at a cost delivered of not more than Twenty two ($0.22) Cents per million B.T.U. This presumes one-third of the supply being drawn from the more expensive slack coals of the Crow's Nest field. The station would be designed for low fuel consumption which would be quite feasible due to good water conditions.

A station at this site can be extended to any desired future capacity. A sketch of the site available for the station is appended hereto (Plan "E"). A spur track of standard gauge would connect the station with the Canadian National Railway; connection to Canadian Pacific Railway can also be had at moderate cost. An ample area for the power house, for fuel storage and for operators' houses is available on a bench some twenty five feet above the river. Foundation conditions are known to be very good from data obtained from railway surveys.

General.

It may be said that a site at or close to Saskatoon would be equally attractive. This is not the case, since that city is at the extreme northerly end of the group of greater cities and loads. The prime costs of an equally efficient transmission system would be greater than from Lake-of-the-Rivers or Elbow, and the annual energy losses on the transmission line would be far larger. If the Roche Percee station were first established, then, Regina and the Kamsack branch receiving its requirements from Roche Percee, the choice of Saskatoon as a second, and ultimately major central station would be less subject to objection, particularly if the Battleford and Prince Albert branches be included within the scheme.

The costs of fuel cannot be less than at the sites above described

Coals of Saskatchewan

Lignite of moderate ash content and containing from 30 per cent to 35 per cent of moisture is the only native coal Beds, of varying thickness and under considerable variation of cover, have been disclosed over considerable areas in each of three southern Saskatchewan districts These are, Estevan, toward the extreme southeast of the province, Willowbunch, south central, and Cypress Hills (Eastend) in the southwestern portion The only shipping mines are in the Estevan district, domestic supplies of fuel for very limited areas are drawn from many small openings in the other areas.

While the presence of lignite has been indicated northwest of the South Saskatchewan River there has been no mining, nor any exploration

On a map accompanying this report are shown all mining properties in the Estevan district, identified as to relative dimension of their 1926 production

The Bienfait Estevan area is thus the only important coal producing district in Saskatchewan Of the 1926 production for all Saskatchewan, 451 000 tons, that from the Souris district was more than 440,000 tons, or 97½ per cent Of the Souris production over 90 per cent was drawn from eight mines, and production was at capacity rate only during early winter months These mines are equipped to produce twice this quantity during the year, and could assure an ample supply of fuel to a large central steam station, although to do so there would needs occur considerable increase in coal mining capacity in order to serve the new station demand along with the present domestic winter demand

A station of 50 000 kilowatts capacity upon which the annual plant factor were 60 per cent would require during one year 360,000 tons of Souris lignite A station of 25,000 Kw with a 40 per cent. annual plant factor (1930 conditions upon the transmission system under study) would require during one year about 120 000 tons. Such supply must be a steady flow of coal to the station, storage of large quantities being impracticable

Saskatchewan Coal for Central Station Use

It has been shown that for a central steam-electric station in the Estevan district, the fuel supply can be drawn from presently operating mines Doubtless arrangements could be made for the draft of the fuel from one mine under long term contract, or possibly a new mine, within convenient transport distance from a station site on the Souris River could be opened and operated at low cost. Neither of these plans is considered in this study

There is included within the estimates the capital cost of a tramway, to be operated by steam or by electricity, or with oil-

electric locomotives, so located as to permit the draft of the fuel supply in standard gauge dump cars from several now operating mines.

Willowbunch District:

Here the supply of local fuel in quantities required for central station use is potential and not presently available. Before it can be assumed as available there must be proven the presence of a large area of coal seam of thickness suitable for economical mining, sufficient to provide supplies for a long period of time, either sufficient for all requirements, or so great as to require only a moderate portion of imported coals.

Since the presence of ample condensing water supply is essential to such a station a site at Lake-of-the-Rivers has been studied, outcroppings of coal promising here the probability of local supply, some small mining operations have been carried on.

Borings over an area of ten to twenty square miles in this neighbourhood are necessary, and sufficient seam extent and of mineable thickness must be disclosed before assurance of sufficient supply of local fuel can be had. See computations hereunder.

Lignite coal area required for supply to Central Steam-Electric Station.

Volume of 1 ton in mine	28–30 cu. ft.
Mine tonnage in 1 acre-foot	1,452 tons
Mine tonnage in 1 sq. mile-foot	929,280 tons
50% Mineable tonnage in 1 sq. mile-foot	460,000 tons
50% Mineable tonnage in 1 sq. mile—	
of 5 foot seam	2,300,000 tons
of 7 foot seam	3,220,000 tons

Thus from a five-foot seam there can be drawn 350,000 tons per annum for a 50,000 Kw steam station at 60 per cent load factor), over a period of 6.5 years from one square mile from a five-foot seam, or over a period of 9.20 years from a seven-foot seam.

During 50 years' service of such a station under that average load factor the coal from a seven-foot seam would be exhausted from about six square miles, under a 40 per cent load factor, corresponding to a 50,000 Kw peak load, the coal from four square miles would be exhausted from such a seam.

In the estimates of the cost of a steam-electric station here no sums are included for mine development, nor for coal transportation, but it is assumed that, if the supply be proven available, fuel can be laid down at the station for not over Two ($2.00) Dollars per ton.

In the estimates of the cost of energy per kilowatt hour from the Lake-of-the-Rivers station it has been assumed (a) that two-thirds of the fuel shall be drawn from a local supply, and one-third from Alberta sources, either the Crow's Nest, Lethbridge or Drumheller areas, (b) that all fuel is drawn from Alberta areas.

The costs per million B.T.U. would be

(a) Two-thirds @ 15 cents	10 cents.
One-third @ 24 cents	8 cents.
Average eighteen cents.	
(b) Twenty-two cents	22 cents.

Studies developed regarding the economics of central steam-electric stations at Roche Percee and at Lake-of-the-Rivers are based on the use of Saskatchewan fuels exclusively in the former case, and of such fuels exclusively or in large proportion in the latter case.

Alberta Coal Cheapest for Elbow

A study has been developed with relation to a possible station site more central with relation to the loads upon a transmission system with the three principal cities as a nucleus. The site chosen is on the right bank of the South Saskatchewan River near Elbow. The Saskatchewan fuels are much more expensive here on account of freight costs. The estimates are therefore based upon the use of Alberta fuels.

A table appended hereto shows the costs per ton of coal delivered at these three station sites. While not all the possible sources of fuel have been canvassed, account has been taken of the larger and more active mine fields. Prices have been obtained from important operators in those fields and railway freight costs have been determined; an estimate of the cost per ton delivered at the station site from each field has thus been derived, and is set out, memoranda regarding ash and moisture contents to be anticipated in coals delivered have been included.

The meat of the study will be observed in the computed cost per million British Thermal Units at each of the three station sites. The probable source or sources of fuel for Elbow and for Lake-of-the-Rivers is thus made plain. The cost per million B.T.U. in heat value is the basis of the economic study for each site. In a properly designed and constructed modern steam-electric station almost any fuel can be burned and with nearly equal efficiency in the powdered form. The variations in ash content will affect the efficiency but little, and the differences in moisture content between bituminous and lignite fuels will influence efficiency by not more than three (3%) per cent.

Boilers equipped with stokers are more limited as to choice of fuels than are those equipped to burn coal in powdered form.

Transmission Mileages

The following schedule of distances has been prepared for purposes of this report. These mileage estimates have been scaled from the series of "Sectional Maps" issued by Topographical Survey of Canada. Actual mileages of construction must be determined by field survey subsequent to choice of route between electric-transformer station.

Roche Percee to Regina	135 miles
Regina to Moose Jaw	42 miles
Moose Jaw to Saskatoon, via. Davidson	145 miles
Saskatoon to Prince Albert	90 miles
Saskatoon to the Battlefords	96 miles
Prince Albert to The Forks	33 miles
Regina to Kamsack, via Indian Head and Balcarres	170 miles
Lake-of-the-Rivers to Moose Jaw	37 miles
Elbow to Saskatoon	81 miles
Elbow to Moose Jaw	77 miles
The Forks to Saskatoon, direct	105 miles

Omitting branch lines the mileages of 110.000 volt transmission required to serve the three cities would be

From Roche Percee	322 miles
From Lake-of-the-Rivers	224 miles
From Elbow	200 miles

Circuits of 336,400 circular mil section of aluminum cable, steel reinforced, are herein recommended for all main lines from whatever station energy is to be drawn This question of mileage of High Voltage Transmission lines is important, not only as affecting capital costs and fixed annual charges of the venture, but as affecting the dimension of line energy losses, and the problem of maintaining uniform voltage conditions at each city To ensure proper uniformity of pressure at each load centre certain synchronous condenser capacities must be operated in conjunction with the service especially at times of capacity loading on the lines Greater condenser capacities are required with the longer lines, and the least gross dimension of condenser capacity is required for the system with Elbow as the site of the Central Station

For a time the present larger turbo-generators in each city can be utilised as condensers, or sources of 'leading' current As the system load grows specially designed synchronous motor units of larger capacity must be installed.

Elbow central station is assumed for the attached typical curves of line voltage regulation, T 1 and T 2 With 110,000 volts at Elbow and at Saskatoon a load of 20.000 Kw can be drawn by use of condenser capacity of 7 000 kva at Saskatoon provided the demand has a power factor of 100 per cent , but if the load power factor be 95 per cent lagging, a condenser capacity of 13,700 Kva. would be required with line conductors of the size chosen, viz 336 400 c m aluminum cable, steel reinforced

With 115,000 volts between conductors at Elbow and 110,000 volts at Saskatoon, a load of 20,000 Kw at 95 per cent power factor would require condenser capacity of only 6,700 Kva., as shown on Diagram T 1

Similarly from the second sheet of line regulation curves (T 2) a Regina load of 20,000 Kw at 95 per cent power factor could be drawn over aluminum conductors of 336,400 c m. at 110,000 volts by use of a condenser at Regina of only 4,500 Kva (within the capacity of Regina's present major unit), provided voltage at Moose Jaw be maintained at 115,000 volts between conductors. Condenser capacity of 12,500 Kva. would be required at Regina

if voltage at both Moose Jaw and Regina be maintained at 110,000 volts under the same load conditions at Regina

These examples are typical only Many such studies have been developed with respect to each possible central station site in the search for the proper size of conductor to be recommended for these circuits to meet 1935 conditions. Other considerations including cost of line energy losses were involved in the study

Right-of-Way

It has been assumed that easements for pole or tower structures can be obtained for nearly all settings. Private right-of-way is not necessary, but access for construction, for patrol, and for maintenance must be included within the price paid for each easement privilege Generally the lines will parallel railway rights-of-way City transformer stations can be so located that there be small costs for approach by the transmission circuits.

Structures

Studies made of *Capital* costs show that wooden structures of treated timber with spans of about 200 to 220 feet require least capital cost although costs of insulators, both prime and replacement, are four times as great as for tower structures

Studies of annual charges on the two types of line construction show a definite advantage to the design using towers for the main lines.

The importance of instilling absolute confidence in the reliability of the transmission system points definitely to selection of the tower system Consequently the estimates herein developed are based on the use of tower supported circuits from the central steam station to each principal city The estimates for branch lines to The Battlefords, to Prince Albert and to Kamsack territory are based on the use of creosoted wood poles. (See sketches of single and double circuit towers)

Tower footings will be of steel attached to grids of angles, channels or beams

Circuits

Two circuits on one line of towers are provided for to connect the central steam station to each principal city One circuit would at first be strung, the second being erected as the load demands may require Circuits would consist of three conductors spaced for 110,000 volts between wires. Studies of all conditions of the problem determined the choice of this now standard voltage A higher voltage would have no advantage of economy, and would introduce some disadvantages. (Except that for the future hypothetical connection of the hydro-electric station 154,000 volts has been chosen, practically all the energy from that source having to be transmitted the entire length of the line—120 miles via Prince

Albert, or 105 miles if direct, and over one circuit for reasons of maximum economy in the cost of the kilowatt hours to be transmitted)

In all main circuits the conductor would be of aluminum cable steel reinforced, and of 336,400 circular mils section, diameter slightly less than ¾ inch, equivalent to No. 0000 copper section The capacity of such a circuit is a quite flexible quantity For the distances between cities in this study a load of 30,000 Kw to 50,000 Kw can be safely transmitted over such a circuit in combination with synchronous motors at city stations operated as condensers as above outlined Transformer steps of 2,500 volts can be provided to permit operation with (a) constant equal voltage at both ends of the circuit, or, (b) up to 10,000 volts higher at sending than at receiving end. A uniform pressure can be maintained at each city

Insulation.

For 110,000 volts the conductor will be supported at each point of suspension with a string of seven (7) standard porcelain discs connected by galvanised steel fittings

For 154,000 volts a string of ten (10) such discs would be used Devices will be provided for ensuring maximum uniformity of electric pressure over each disc in the string.

For strain supports as at terminals, sectionalising towers, etc, additional discs will be used

Lightning Protection:

At each transformer station a set of valve type or similar arresters will be installed

On each double circuit line a single ground cable of about ⅜-inch diameter will be mounted on the tower apex. On the 154,000 volt circuit from The Forks two such wires would be strung. All ground wires will be thoroughly "grounded" through the tower, and always into moist soil, in such manner as to ensure low resistance and large current carrying capacity

Transformer Stations: City

All structures will be of the "out-door" type, control devices being sheltered within small adjacent buildings or in the city-owned distributing station.

Transformation from transmission voltage will be downward to either 2,300–4,000 volts, three-phase, or to 13,000 volts where so desired by the city customer of the system.

Suitable automatic oil circuit breakers will protect the system from local city troubles

Transformer Stations, Town and Village.

For groups of small towns and villages and for farm service low tension will be at 13,200 volts as a rule, and three phase. Secondary distribution circuits on wood pole lines will serve each load centre.

For individual small village service a single transformer will supply current for lighting and small power requirements at 2,300 volts.

A Portion of Present City Station Costs Will Persist

Construction of a central station-fed high voltage transmission system will not entirely relieve the municipalities served from all their present annual costs chargeable to the generation of electric energy. Certain fixed charges must be met until present debenture issues shall have been extinguished, certain other charges, such as taxes, insurance on present plants and a share of administration charges will continue.

The following schedule of continuing fixed charges against generation of energy has been prepared from the reports of 1926 operations with respect to the three cities

	Moose Jaw	Saskatoon	Regina
Administration	$ 5,737 00	$ 2,375 00	
*Principal and Interest	31,562 00	53,290 00	
*Sinking Funds.	16,214 00	24,555 00	
*Depreciation	11 400 00	25,000 00	
‡Taxes.	2,202 00	15,400 00	
‡Insurance	3,052 00	3,992 00	
Total	$70,167 00	$124,612 00	$118,323 00

*60% of Total ‡66 6% of Total.

The Major Portion of Generating Station Operation Costs Will Cease

Upon the establishment of power delivery to the municipalities served from a central station source, the operation of present city station equipment will cease, or will be diminished to emergency stand-by service which would only be continued if insisted upon by city authority, or will recur at hours and days of peak load under authority of the system load despatcher.

The 1926 costs to the three principal cities which would be affected were

	Moose Jaw	Saskatoon	Regina
Wages	$31,021 40	$51,624 86	$35,944 71
Maintenance	25,241 75	30,512 66	24,531 13
Stores and Supplies	4,141 67	3,674 21	5,213 95
Fuel	104,842 29	152,250 07	137,179 96
Water		693 73	
Extraordinary (?).	15,000 00	.	
	$180,247 11	$238,655 52	$202,869 75
Kwh. distributed from Switchboard	12,752,312	19,256,960	24,523,155
These costs per Kwh. were.	1 413c	1 239c	0 827c
Adding Fixed Costs brings total cost of each distributed Kwh.	1 964c	1 886c	1 310c

These figures are taken from official returns to Power Resources Commission and to their engineer

Of these costs it has been estimated that, even with receipt of energy from a central station, there will persist a portion as set out in Table No 11 hereinabove

Central Steam-Electric Station Advisable

From Preliminary Report

'The 1926 peak of demand by the three cities was about 18,000 kilowatts, this would become 20,000 Kw in 1927, 22,000 Kw in 1928 and over 24 000 Kw in 1929 These demands can be met by the present plants if their generating equipment should be pooled, and all the major units in each plant would be needed at the hour of peak demand, spare capacity would be confined to the smaller generators owned by the three cities If the generating capacity be not pooled Saskatoon must add a unit of large dimension for which the city will have no equivalent spare, while Regina has two 5 000 kilowatt units, the earlier one is less economical to operate and its use would increase the costs of kilowatt-hour production, Moose Jaw will have no spare for its new 5.000 kilowatt unit '

"As the loads grow from year to year the tendency will be to add to each plant a unit of still larger capacity for which there will be no true spare and, in combination with these new units which may be assumed to be of maximum fuel economy the use of their present equipment during peak hours and, later on during longer hours will prevent full advantage of the lower economies Further, the increase of investment by each city will make more difficult in the future a decision to join their interests, and the possibility of establishing a province-wide transmission system with the three cities as its core will diminish."

"These individual city expenditures can be avoided if the recommendations of our report be made effective This would result in the releasing of the municipal borrowing powers for their non-commercial city development needs '

' The immediate capacity of the central station need not be equivalent to the peak demand upon the system except that there should be chosen units of large dimension, and at least two should be installed in such a central station A first installation of two 12.500 Kw units is recommended Energy transmitted from this central station would provide most of the requirements, the peak loads being carried by the present fairly efficient major units owned by the cities, each year these units could carry load for longer hours, postponing the date for enlargement of the equipment of the central steam station and obtaining the major part of the operative value of the larger and newer city units, the city units would also serve as emergency protection although the central station equipment and the necessary transmission lines will be exceedingly dependable."

Central Station—Transmission Financial Aspects

The subjoined estimates cover respectively *capital investments* necessary for 25,000 Kw and for 50,000 Kw station capacity, and in separate tables the items

Table No 14.—Steam-Electric Station—at three optional sites.

Table No. 15.—High Tension Transmission Lines, per mile of single or of double circuit.

Table No. 16 Step-down Transformer Stations at Regina, Moose Jaw and Saskatoon.

Table No. 17.—Gross costs of the entire project which are pertinent to each Central Station site.

Estimates of *annual costs* appertaining to the operation of Central Stations are set out in Table No. 14A. Fixed costs, made up chiefly of unavoidable charges for interest depreciation or debenture sinking fund emergency suspense reserve also include operating wages and administration, which vary but little with variation of load. Unit cost for all these items therefore varies inversely with the energy output from the plant. Fuel costs per kilowatt hour are assumed to be a constant item. While the table shows unit costs for plant factors up to 100 per cent the actual practical range of operating annual plant factor in service to the three chief Saskatchewan cities will be from 35 per cent. to 50 per cent or 55 per cent., variations therein being but moderate from year to year, and being bettered considerably by free use of local City generators for peak load carrying.

It is for the load despatcher of the system to determine to what extent it is desirable to lower central station unit costs by use of high cost energy from City stations.

Table No. 15A sets out the computation of annual charges per mile of 110,000 volt three-phase, single and double transmission circuits erected on steel galvanised towers.

Table No. 18 shows the financial operating statistics for the three main cities for 1926.

Table No 14

Estimate of Capital Costs of Steam-Electric Generating Stations

Saskatchewan Lignites at Roche Percee and Lake-of-the-Rivers   Alberta Coals at Elbow

Item	25,000 Kw station	2 Generators	4 Boilers	50,000 Kw station	5 Generators	7 Boilers
	Roche Percee	Lake-of-Rivers	Elbow	Roche Percee	Lake-of Rivers	Elbow
12,500 Kw Turbo-Alternators with Condensers	$ 534,000 00	$ 528,000 00	$ 528,000 00	$1,325,000 00	$1,320,000 00	$1,320,000 00
1,000 Kw House Turbine	25,000 00	25,000 00	25,000 00	25,000 00	25,000 00	25,000 00
Bleeder Heaters, Deaerators and Evaporators	79,000 00	84,000 00	85,000 00	150,000 00	160,000 00	170,000 00
Boilers and Coal Firing Plant with Stacks	730,000 00	730,000 00	655,000 00	1,285,000 00	1,285,000 00	1,154,000 00
Pumps and Tanks	36,000 00	36,000 00	36,000 00	60,000 00	60,000 00	60,000 00
Steam and Water Piping	100,000 00	100,000 00	100,000 00	160,000 00	160,000 00	160,000 00
Coal Bunkers, Coal Handling and Storage, Ash Handling	115,000 00	110,000 00	90,000 00	185,000 00	175,000 00	150,000 00
Crane and Rails	25,000 00	25,000 00	25,000 00	30,000 00	30,000 00	30,000 00
Low Tension Switching, Battery, Station Light and Heat	55,000 00	55,000 00	55,000 00	120,000 00	120,000 00	120,000 00
Building, Foundations and Site Preparation	375,000 00	365,000 00	365,000 00	700,000 00	680,000 00	675,000 00
Condenser Water Intake, Conduits, Screens, etc	125,000 00	75,000 00	60,000 00	200,000 00	125,000 00	100,000 00
Operators Houses	50,000 00	50,000 00	50,000 00	80,000 00	80,000 00	80,000 00
Railway Connection	10,000 00	75,000 00	60,000 00	10,000 00	75,000 00	60,000 00
Contingencies, Unlisted Equipment and Preliminary Operations, 12 per cent	275,000 00	275,000 00	255,000 00	530,000 00	515,000 00	495,000 00
Engineering and Legal	80,000 00	75,000 00	75,000 00	150,000 00	145,000 00	145,000 00
Interest during Construction	25,000 00	25,000 00	25,000 00	50,000 00	50,000 00	50,000 00
Allow for Up-river Storage Dams				150,000 00		
Totals	$2,639,000 00	$2,633,000 00	$2,489,000 00	$5,220,000 00	$5,005,000 00	$4,794,000 00
Per Kilowatt useful Capacity	105 56	105 32	99 56	104 40	100 10	95 88
Coal Railway	300,000 00			300,000 00		

Table No 14A

Annual and Unit Costs—Generation Only

	Roche Percee	Lake-of-the-Rivers		Elbow
Capital Cost	$2,639,000 00	$2,633,000 00		$2,489,000 00
Interest and Depreciation, 7 4%	195,400 00	195,600 00		184,100 00
Suspense Account, 0.6%	15,800 00	15,800 00		15,000 00
Taxes and Insurance	25,000 00	20,000 00		20,000 00
Payroll, including Maintenance Staff	50,000 00	40,000 00		40,000 00
Administration (share of)	15,000 00	15,000 00		15,000 00
Stores and Maintenance Materials	35,000 00	30,000 00		30,000 00
Annual Fixed Charges	$ 336,200 00	$ 316,400 00		$ 304,100 00
Unit Fixed Charges	c. per Kwh	c per Kwh		c per Kwh
100% Plant Factor, Output 219,000,000 Kwh	153	144		139
75% Plant Factor, Output 164,300,000 Kwh.	205	192		186
50% Plant Factor, Output 109,500,000 Kwh.	.306	288		.279
40% Plant Factor, Output 87,600,000 Kwh	380	360		349
		(a)	(b)	
Unit Fuel Cost assumed for all Plant Factors	285	.321	424	386
Total Unit Costs				
100% Plant Factor, Output 219,000,000 Kwh.	438	469	569	525
75% Plant Factor, Output 164,300,000 Kwh	485	.517	617	572
50% Plant Factor, Output 109,500,000 Kwh	591	.613	713	665
40% Plant Factor, Output 87,600,000 Kwh.	665	.685	785	735

Note – (a) Based on 2/3 Saskatchewan Coal, 15c per million B.T U. (b) Based on all Alberta Coal, 2/3 @ 21c per million B.T U
1/3 Alberta Coal, 24c per million B T U 1/3 @ 24c per million B T.U

From a 50,000 Kw station the costs per kilowatt hour will be but slightly shaded, since capital costs per unit of capacity are only slightly different (See Table No. 14)

Table No. 15.

Estimate of Capital Cost Per Mile for 110,000 Volt Three-Phase Transmission, Using Double Circuit Towers, 30,000 Kw. Capacity Per Circuit

	Carrying single circuit	Carrying double circuit
Towers—880 ft. Spacing	$4,200 00	$4,200 00
Conductors, 336,400 c m Aluminum, Steel reinforced	2,146 20	4,292 40
Ground Cable ¼" Steel Standard	102 73	102 73
Insulators. 7 discs	401 80	803 60
Labor	1,141 00	*1,312 00
Telephone Line, No 8 Copper	519 79	519 79
Surveys and Easements for Towers and Poles	300 00	300 00
Engineering, Purchase and Supervision	325 55	406 35
Contingent Items: Plant Charge, Compensation and General	294 36	384 00
Contractors Profit.	284 21	329 56
Interest during construction	97 12	126.49
Total	$9,812 79	$12.776 92

*Cost will be somewhat higher if second circuit be strung as a separate job.

Table No 15A.

Estimate of Annual Charges Per Mile for 110,000 Volt, Three-Phase Transmission Line, Using Double Circuit Steel Towers, One or Two Circuits of 336,400 c.m., a c s r Installed, Each Circuit Rated at 30,000 Kilowatts.

			Carrying single circuit		Carrying double circuit	
Capital Cost complete with Telephone Line				$9,812 79		$12,776 92
Sinking Funds, earning 4 per cent. per annum						
Item	Life (years)	Rate				
Towers	40	1 052	$59 11		$59 11	
Conductors	40	1 052	27 1.		54 22	
Ground Cable	20	3 368	5.45		5 45	
Insulators	7	12 661	53 54		107 08	
Telephone	30	1 783	10 14		10 14	
Easements	40	1 052	3 40		3 40	
Sundries	40	1 052	1 47		1 60	
				$160 22	—	$241 00
Interest at 5% per annum				490 64		638 84
Maintenance, chiefly Insulators and Telephone Items				19.83		28 29
Patrol, 15 mile sections				120 00		120 00
Total Annual Charges per mile of Line				$790.69		$1,028 13

Table No. 16.

ESTIMATE OF COST OF TYPICAL TRANSFORMER STATION

110,000 Volts to 2,300–4,000 Volts, 3—7,500 Kva. Units, Plus One Spare.

As for Regina and Saskatoon

Transformers, 30,000 Kva.		$135,000 00
Foundations and Structural Steel for Double Circuit outgoing lines		45,000 00
High Tension Switch and Disconnects, Bus Structure and Switching, (in duplicate on L. T. side)		80,000 00
Lightning Arresters and Disconnects, (one circuit)		13,000 00
Building and indoor control		35,000 00
Allow for land.		5,000 00
Engineering and Contingencies		25,000 00
		$338,000 00
Or, per useful Kw	$15 00	
Allow for Moose Jaw step-down Transformer Station. 4—3,750 Kva. Transformers	$180,000 00	
Or per useful Kw	$16 00	

Table No. 17.

GROSS CAPITAL COSTS FOR STEAM-ELECTRIC CENTRAL STATION AND 110,000 VOLT TRANSMISSION LINES TO SERVE REGINA MOOSE JAW AND SASKATOON

Item	25,000 Kw Station, Single Circuit Line			50,000 Kw Station; Double Circuit Line		
	Roche Percee	Lake-of-Rivers	Elbow	Roche Percee	Lake-of-Rivers	Elbow
Steam-Electric Station	$2,639,000 00	$2,633,000 00	$2,489,000 00	$5,220,000 00	$5,005,000 00	$4,794,000 00
Step-up Transformer Station	340,000 00	340,000 00	340,000 00	600,000 00	600,000 00	600,000 00
Transmission Line						
322 Miles	3,160,000 00			4,114,000 00		
224 Miles		2,200,000 00			2,862,000 00	
200 Miles			1,960,000 00			2,556,000 00
Step-down Transformer Stations	856,000 00	856,000 00	856,000 00	856,000 00	856,000 00	856,000 00
	$6,995,000 00	$6,029,000 00	$5,645,000 00	$10,790,000 00	$9,323,000 00	$8,801,000 00
Or including Coal Collecting, Railway Trackage and Equipment upon which the charges are included within the estimated cost of delivered coal	$7,295,000 00			$11,090,000 00		

The following Table No. 18 shows the relative investments in electric utilities operated by the three cities during 1926

Table No. 18

	Regina	Moose Jaw	Saskatoon
Total Capital	$2,300,592. 03	$1.109,933 00	$1,923,532 93
Present Book Value.	1,233,849 98	631,696 00	1,141,434 79
Debenture Debt	1 158,7.8 95	1,234,722 00	1,872,887 10
Actual Present Value.			
Generating Plant	988,026 88	800,000 00	556,055 40
Distribution System	471,120. 13	450,000 00	585,379 39
Total	$1,467,147 01	$1,250,000 00	$1,141.434 79
Total Generator Capacity (See Table No. 9)	16,000 Kw	8,500 Kw	12,300 Kw
And the Operating Results.			
Peak Demand	8,000 Kw	3,925 Kw	6,100 Kw
Station Output (Kwh.)	24,520,650	12,752,312	19,256,980
Total Revenue	$672,481 84	$412,999 79	$618,019 31
Tota. Expenditure	445,647 83	312,991 61	499,421 46
Net Total	226,834 01	100,008 18	118,597 85

Branch Transmission Lines

Three major branches have been studied, viz., from Regina north-eastward to a terminus at Kamsack from Saskatoon northward to Prince Albert, and from Saskatoon north-westward to the Battlefords. Their routes are shown on the accompanying map.

The Kamsack Branch, 170 miles in length, would serve many fair-sized communities and towns, and would in time accumulate a very considerable load, and at a fair load factor, but not approaching the load factor of the City demands above discussed A multiplicity of small generating plants would be displaced The other branches, though shorter, are less attractive as useful entities in Provincial development Very little load would be accumulated except at the termini

As is shown by examination of Table No 12, the estimated peak loads, load factors and energy consumptions for 1935 are

	Demand	Load factor	Consumption
Regina-Kamsack	2,700 Kw	29 6%	7,000,000 Kwh.
Saskatoon-Prince Albert	2,600 Kw	37 0%	8,400,000 Kwh.
Saskatoon-Battleford.	1,900 Kw	27 7%	4,600,000 Kwh.

Considering the probable life period of the line structure it was decided by your engineers to base estimates of capital and operating costs on a line capacity of 5,000 Kw This choice affected cost of cable only, and choice of smaller cable would not reduce the annual charges so greatly as to determine the economic feasibility of the Branch Line idea. The aluminum conductor chosen has a cross section of 105,535 circular mils, equivalent to No. 2 copper

Table No 19 shows the cost per mile of the line mounted on wood poles, butt treated, and insulated for 66,000 volts between three-phase conductors. Table No. 19A is an estimate of the annual charges for interest, depreciation and patrol per mile of Branch Lines. Table No. 19B shows the annual costs appertaining to the three Branch Lines under consideration, including transformer stations and administration charges.

Table No. 19.

ESTIMATE OF CAPITAL COST PER MILE FOR 66,000 VOLT, THREE-PHASE TRANSMISSION ON WOOD POLES

Capacity of the Circuit, 5,000 Kw.

8" x 40' Poles, butt treated, 220' spacing	$416 00
Arms, fittings, anchors, etc.	291 00
Insulators	531 00
Conductor, 105,535 c m., a.c.s.r	715 00
Easements, survey and negotiations	250 00
Labour, distributing material, setting poles, and stringing cable	318 00
Purchasing and supervision	95 00
Contingency, compensation, interest during construction, contractors allowance	210 00
	$2,826 00
Telephone on separate poles as estimated for Tower Line service	520 00
Total cost per mile	$3,346 00

Table No. 19A.

Estimate of Annual Charges per mile for 66,000 volt, three-phase Transmission, using single circuit on wood poles, butt treated. conductor 105,535 c m., a.c.s.r

Rated capacity of circuit, 5,000 kilowatts.

Useful life assumed at 30 years

CAPITAL COST COMPLETE WITH SEPARATE TELEPHONE LINE, $3,346 00

Sinking Fund, earning 4% per annum.

Item erected	Capital sum	Life (years)	Rate %	Amount	
Poles	$652 00	30	1 783	$11 63	
Conductors	745 00	30	1 783	13 28	
Arms, etc.	332 00	30	1 783	5.92	
Insulators	637 00	7	12 661	80.65	
Telephone	520 00	30	1 783	9 27	
Easements	250 00	30	1 783	4 46	
Overhead	210 00	30	1 783	3 74	
					$128 95
Total	$3,346 00				
Interest at 5% per annum					167 30
Maintenance 2% on Insulators and Telephone					23 15
Patrol, 20 mile sections					90 00
Total Annual Charges per mile of Line					$409 40

Table No. 19B

Regina-Kamsack Line—170 Miles.

On Transmission Line @ $409.40	$69,598 00
On Transformer Stations at Towns and Villages Total Capacity 1940 basis 4,000 Kw Capital Cost (@ $25.00 aver.) $100,000.00.	
Rate 8%	8,000 00
Administration	5,000 00
Total Annual Charges	$82,598 00

Saskatoon-Prince Albert Line—90 Miles

On Transmission Line @ $409.40	$36,846 00
On Transformer Stations at Prince Albert and smaller towns: 3,500 Kw Capital Cost (@ $20.00 aver) $70,000.00.	
Rate 8%	5,600 00
Administration	3,000 00
Total Annual Charges	$45,446 00

Saskatoon-Battleford Line—98 Miles.

On Transmission Line @ $409.40	$40,121 00
On Transformer Stations at North Battleford and smaller towns: 2,500 Kw Capital cost (@ $25.00 aver) $62,500.00.	
Rate 8%	5,000 00
Administration	3,000 00
Total Annual Charges.	$48,121 00

Branch Line Charges Per Kilowatt Hour of Energy Delivered.

These estimates do not cover low tension distribution lines at any point. The costs are for energy delivered to 2,300 volt secondaries (primaries for town distribution)

Table No. 20

Branch No 1

Regina, Qu'Appelle, Balcarres, Yorkton, Canora, Melville, Kamsack.

High Tension Line and Transformer Charges		$82,598 00
1930 Energy Requirements	3,900,000 Kwh.	
Line Charges per kilowatt hour	2 12 cents.	
1935 Energy Requirements	7,000,000 Kwh.	
Line Charges per kilowatt hour	1 18 cents.	
Add average cost of energy at Three Cities 1930—1 5 cents, 1935—1 17 cents		

(While these average costs at Regina. Moose Jaw and Saskatoon cover transformation from 110,000 volts to 2,300 volts there should be some recognition of the fact that unless the Tri-City-Provincial Central Station scheme be instituted the outlying towns could not get energy so cheaply as here estimated)

Average costs of energy ready for distribution throughout towns on Branch Line No. 1.

1930 -3.62 cents, 1935 2.35 cents.

These costs compare very favorably with 1926 costs of energy at Qu'Appelle, Yorkton, Melville and Kamsack.

Table No. 20A

Branch No 2.

Saskatoon, Langham, Radisson, Battlefords.

High Tension Line and Transformer Charges		$48,121.00
1930 Energy Requirements	2,400,000 Kwh.	
Line Charges per kilowatt hour	2.00 cents.	
1935 Energy Requirements	4,600,000 Kwh.	
Line Charges per kilowatt hour	1.05 cents.	

Add average cost of energy at Three Cities

1930 —1.5 cents; 1935 1.17 cents

Average costs of energy ready for distribution throughout towns on Branch Line No. 2

1930 3.50 cents, 1935 –2.22 cents.

These costs are less than the 1926 costs for generated energy at North Battleford, the largest centre of population on the line, which were about five cents (5c) per Kwh (including share of taxes paid)

Table No 20B.

Branch No 3

Saskatoon. Rosthern, Duck Lake, Prince Albert.

High Tension Line and Transformer Charges		$45,446.00
1930 Energy Requirements	5,100,000 Kwh.	
Line Charges per kilowatt hour	0.89 cents.	
1935 Energy Requirements	8,400,000 Kwh	
Line Charges per kilowatt hour	0.54 cents.	

Add average cost of energy at Three Cities

1930 1.5 cents; 1935 1.17 cents.

Average costs of energy ready for distribution throughout towns on Branch Line No. 3

1930 2.34 cents; 1935—1.71 cents.

Prince Albert in 1926 generated energy required -3,174,733 Kwh at a cost of less than 2.5 cents per Kwh.

Costs of Delivered Energy.

The generating capacity of a Central Station must always be greater than that necessary to supply the year's peak of demand, except that, in the case under study, certain generators owned and now operated by the three cities may be included during early years of joint system operations as making up the peak carrying, and spare, capacity needed. It is assumed here that the Central Station shall from the first be equipped for 25,000 kilowatts output. Since it has been presupposed that present City generators shall assist at peak hour service only it is manifest that the yearly kilowatt-hour output of the Central Station, while by far the greater portion of the energy consumed, will not correspond to one hundred per cent. plant factor, but to a plant factor only slightly higher than the yearly load factor of the joint load. (Thus, for example, from Line 7 of Table 12 B the 1935 requirements of the three cities will

have a yearly "load factor" of only 0.395, whereas if peaks be carried by City generators from Line 13 the draft of energy from the Central Station will cause a "plant factor" of 0.513). As the system load grows, the value of the present City generators as load carriers diminishes and additional generating units must be installed in the Central Station the gross yearly output from the generating station must still remain only about one-half of what the equipment could produce if operated to capacity every hour of every day in the year (100 per cent. plant factor).

In the supported estimate of 1935 costs per kilowatt hour to the three cities, it has been assumed that the Central Station "plant factor" will never exceed fifty per cent. (50% - 50). Inspection of Table No. 14A shows the range of variation of generation costs per kilowatt hour. Since the exact cost for any year of operation must depend upon the plant factor experienced, it is clear that charges to customer or partner cities approximated against the service from the beginning of each year must be adjusted by rebate to or by additional collection from the participating City partners at the end of the year as is the practice of the Hydro-Electric Power Commission of Ontario. For purposes of this report the 1935 costs of generated energy are taken at the following

At Roche Percee Station	0.62c per Kwh.
or at Lake-of-the-Rivers Station	0.65c per Kwh.
or at Elbow Station	0.70c per Kwh.

Line and Transformer Losses

These have been estimated carefully for 1935 conditions and may be taken at

From Roche Percee Station	10%
From Lake-of-the-Rivers Station	6.5%
From Elbow Station	6.5%

These losses correspond to one three-phase circuit of 336,400 c.m. aluminum, steel reinforced conductors, and do not include any losses which would occur if synchronous condensers were operated at City termini. Soon after 1935 it may be found desirable to install such devices for regulation of delivery voltage, but more probably a second transmission circuit would be installed, thus postponing the date at which condensers would be needed.

The 1935 line and transformer losses would thus be (one circuit under load)

From Roche Percee, about	15,000,000 Kwh.
or from Lake-of-the-Rivers, about	10,000,000 Kwh.
or from Elbow about	10,000,000 Kwh.

and the Central Station outputs would be

Total demand of Three Cities and intervening territory

From Roche Percee Station (Table 12A Line 8)	158,400,000 Kwh.
From Lake-of-the-Rivers or from Elbow Station (Table 12B Line 7)	150,800,000 Kwh.

It may be assumed that the local City stations would furnish the same quantity of energy in each case (See Table No 12, Sheet B, Lines 7 and 13, Sheet C, Lines 8 and 16) 2,900 000 Kwh.

The energy delivered by the transmission line would thus be

From Roche Percee Station	155,500,000 Kwh.
From Lake-of-the-Rivers, or from Elbow Station	147,900,000 Kwh

The energy delivered from Central Station generators would be

From Roche Percee Station	170,500,000 Kwh
From Lake-of-the-Rivers or from Elbow Station	157,900,000 Kwh

Total 1935 Costs of Energy

(a) *Generation*

From Roche Percee station 170,500,000 @ 0 62c.		$1,057,100 00
From Lake-of-the-Rivers station 157,900,000 @ 0 65c		1,026,350 00
From Elbow station 157,900,000 @ 0 70c.		1,100,530 00

(b) *Transmission Line Charges*

From Roche Percee station	
322 miles @ $ 790 69	$254,602 00 single circuit
@ 1,028 13	331,058 00 double circuit.
From Lake-of-the-Rivers station	
224 miles @ $ 790 69	$177,115 00 single circuit.
@ 1,028 13	230,301 00 double circuit.
From Elbow station	
200 miles @ $ 790 69	$158,138 00 single circuit.
@ 1,028 13	205,626 00 double circuit.

(c) *Transformer Station Charges*

Step-up Transformers			$700,000 00
Step-down Transformers. Regina, 3 of 7,500 Kw; Saskatoon, 3 of 7,500 Kw; Moose Jaw, 3 of 3,750 Kw; Sundry Towns			856,000 00
			$1,556,000 00
Interest and Depreciation	7 4%		
Suspense and Maintenance	0 6%		
	8 0%	..	$124,480 00

(d) *City Continuing Fixed Charges on Present Investments*

Regina.	$120,000 00	
Moose Jaw	70,000 00	
Saskatoon	125,000 00	
Allow Sundry	25,000 00	
		$340,000 00

Note.—These charges continue throughout earlier years of joint system only

(e) *Cost of Peak Load Energy Generated in City Plants*

Keeping boilers under steam	$51,000 00	
Labour, maintenance and supervision	30,000 00	
Fuel 2,900,000 Kwh @ 0 9c	26,100 00	
		$107,100 00

(f) Administration and Technical.

Allow $20,000 00

(Not included in Steam Station Costs)

Total 1935 costs of energy delivered at Low Tension to Cities and Towns

	Over Double Circuit	Over Single Circuit
From Roche Percee station	$1,945,738 00	$1,849,282 00
or from Lake-of-the-Rivers	1,814,23. 00	1,761,145 00
or from Elbow station	1,863,736 00	1,816,248 00

NOTE.—If no local coal supply be proven at Lake-of the-Rivers there would remain no advantage at this site over Elbow, if the storages of water along the Souris River cost more than $150,000 00 the relative costs of energy from Roche Percee will be higher than hereinabove estimated

Average 1935 Costs Per Kilowatt-Hour of Delivered Energy

	Over Double Circuit Line	Over Single Circuit Line
From Roche Percee station 158,400,000 Kwh.	1 228c	1 167c
From Lake-of-the-Rivers. 160,300,000 Kwh.	1 203c	1 168c
From Elbow station 160,300,000 Kwh.	1 238c	1 204c

These costs will become less as the load upon the system becomes greater, since the major portion of the annual expenses arise out of investment, and are not operating charges.

Generating station and transmission line capacities of 50,000 kilowatts would be ample until 1939 or 1940, peaks of winter loads being carried on present major City units.

1930 Conditions and Costs

The Central Station System should be established before the winter of 1929-30 The peak demand in kilowatts could be carried on one transmission circuit for a year or two, and the step-up transformer bank might reasonably be of capacity more closely related to that demand, being duplicated at a later period, say, 1933.

During the winter of 1930-31 City demands and consumptions would be as set out in Table No 12 above

System Capital Investments would be as set out in Table No. 17.

Line Losses would be approximately

From Roche Percee station	4% or 3,600,000 Kwh
or from Lake-of-the-Rivers station	2 5% or 2,100,000 Kwh.
or from Elbow station	2 5% or 2,100,000 Kwh.

Total Demand of Three Cities and intervening territory

From Roche Percee (Table 12.A, Line 8)	90,900,000 Kwh.
or from Lake-of-the Rivers (Table 12 B, Line 7)	86,600,000 Kwh
or from Elbow (Table 12 C, Line 8)	86,500,000 Kwh.

Assuming that the local City stations furnish in either case certain energy during winter peak hours 1,200 000 Kwh, the energy to be *delivered* at Transmission termini would be

From Roche Percee	89,700,000 Kwh
or from Lake-of-the-Rivers	
or from Elbow, . . .	85,400,000 Kwh.

and that delivered from Central Station Generators would be

From Roche Percee .	93,300,000 Kwh.
or from Lake-of-the-Rivers	
or from Elbow	87,500,000 Kwh.

Total 1930 Costs of Energy

(a) *Generation*

At Roche Percee	@ 0 65c	$606,450 00
or at Lake-of-the-Rivers .	@ 0 68c	595,000 00
or at Elbow	@ 0 72c	630,000 00

(Unit costs higher for 1930 than for 1935 because of lower annual plant factor)

(b *Transmission Line Charges (single circuit)*

From Roche Percee (as for 1935) .	$254,602 00
or from Lake-of-the-Rivers	177 1,5 00
or from Elbow . . .	158,138 00

(c) *Transformer Station Charges:*

Step-up Transformers	$340,000 00	
Step-down Transformers	856,000 00	
	. . . . . .	$1,196,000 00

NOTE — At Regina and at Saskatoon it might be reasonable to install at first 3—3,750 Kw Transformers, this plan would reduce the gross primary investment in step-down transformers to $755,000.00.

Charges @ 8% per annum	
On large installation	$95,680 00
On lesser installation	87,600 00

(d) *City Continuing Fixed Generating Plant Charges* $340,000.00.

(e) *Cost of Peak Load Energy Generated in City Plants*

Keeping boiler under steam . . .	$17,000 00	
Labour, maintenance and supervision	30,000 00	
Fuel, 1,200,000 Kwh @ 0 9c	10,800 00	
		$57,800 00

(f) *Administration and Technical* $20,000.00

Total 1930 Costs of Energy Delivered at Low Tension to Cities and Towns

From Roche Percee station .	$1,374,532 00
or from Lake-of-the-Rivers	1,285,595 00
or from Elbow station	1,301,618 00

Average 1930 Costs Per Kilowatt-Hour of Delivered Energy

From Roche Percee	90,900,000 Kwh.	1 512c
or from Lake-of-the-Rivers	86,600,000 Kwh	1 484c
or from Elbow . ' .	86,500,000 Kwh.	1 505c

NOTE. If at Regina and Saskatoon the step-down Transformer installation be at first four units of 3,750 Kw (as at Moose Jaw), these unit costs would be reduced by 0 05 cents per kilowatt-hour

Present City Costs of Generation of Energy

For comparison with the above estimates of the costs of energy if delivered from Central Steam-Electric stations the following records of 1926 costs at the three principal Saskatchewan cities are as reported to the Power Resources Commission (See discussion hereinabove)

	Station output	Gross cost	Cost per Kwh
Regina	24,523,155 Kwh.	$321,192 97	1 31 cents
Moose Jaw	12,752,312 Kwh	250,414 11	1 96 cents
Saskatoon	19,256,980 Kwh.	363,267 52	1 89 cents
Totals	56,532,447 Kwh	$934,874 60	1 65c average.

The low costs at Regina during 1926 were attained by operating the newer and more efficient 5 000 Kw unit as base load carrier, other units being operated only during hours of peak demand beyond the capacity of that unit Higher fuel costs would accompany more liberal use of other generators, as will be necessary for the greater loads of early future

The average cost of energy generated at a Central Steam-Electric station and delivered at City low-tension bus bars for distribution to customers would be 1 45 cents per kilowatt hour in 1930, and 1 17 cents per kilowatt-hour in 1935. As noted above, these average costs will diminish as the fixed charges on present City generating equipments cease upon redemption of the debentures covering them

HYDRO-ELECTRIC POWER POSSIBILITIES

From Preliminary Report

"Natural powers of suitable dimensions are found only on the Churchill River, too far north for delivery of cheap power to present load centres."

"South of the Churchill River there are no water falls in Saskatchewan where there is combined a large quantity of flow with any considerable height of fall such as would permit of cheap hydro-electric development."

"The Saskatchewan River is not now available as a source of cheap energy, because

First, the flow during winter seasons, even for present loads, is not sufficient

Second, large flows of summer reduce the effective head at any site chosen

Third for cheap summer energy a large portion of the flow must be utilised because of the large capital costs of any development, this energy cannot be absorbed by the entire province until after 1945.

Fourth, such energy must be delivered as far as to Saskatoon for a cost equivalent to the cost of fuel needed for electricity production there.

Fifth, because of winter deficiency of the stream there must be provided large steam-electric stations sufficient for nearly the entire demand whether water power be used or not."

"In rivers of gentle slope such as the Saskatchewan there is not much advantage in cost and none in operation which could be gained by building a dam at the top of any rapid in combination with a channel leading to the power house at the foot of the rapid, as against location of the dam and power house both at the foot of the rapid. With the latter choice the presence of the rapid itself is immaterial, affecting only the mileage to which the back-flooding by the dam would extend. Thus the choice of location for a dam is governed by other considerations such as width of channel, height of banks, character of foundations etc. The cost of construction of the general works will be fixed without much respect to the quantity of flow."

"The range of flow in the Saskatchewan at The Forks varies from about 3,000 second feet minimum to 300,000 second feet maximum. flows of over 16,000 second feet appear in the summer time only and can be depended upon for about six months of every year. The low water flow of winter is equivalent to an output of only 12,000 kilowatts with a working head of fifty feet, about the maximum permissible between benches of the river. This is less than the combined demand of the three cities during 1926 which was 18,000 kilowatts. Assuming an annual increase in demand of ten per cent it is manifest that such a water power would need to be supplemented by the output of a considerable central steam station in order to meet the requirements. The cost of works to control the river plus the cost of generators and turbines to develop the energy of the *winter* flow of the stream would be so great per kilowatt of capacity that the kilowatt hours could not be delivered at Saskatoon or elsewhere at a price to compete with steam-generated energy."

In order that energy can be drawn cheaply from the Saskatchewan River the power station must be equipped with generating capacity such as would utilise the waters flowing during the summer season, and this energy would all have to be utilised. Inspection of the charted records of flow shows that for six months of each year 16,000 cubic feet per second can be depended upon, equivalent to about 50,000 kilowatts of output. This is far beyond the continuous summer needs of the present or of the near future. This 50,000 kilowatts of continuously potential summer energy could not be absorbed by the transmission system until that year in which the *minimum* summer day's requirements should reach that dimension, in which case the central steam station would daily be carrying considerable load. (See the June 23rd load curve)."

"Energy from The Forks must be delivered southward as far as Saskatoon, and since the steam station capacity would be fixed by the winter demand of the system, these hydro-electric kilowatt hours would need to be delivered at Saskatoon for a price less than the cost of fuel for the steam station. Analysis shows that this is improbable and further, that not until after the year 1945 would the minimum summer day's load upon the system be anywhere near 50,000 kilowatts. Complete estimates with detailed analysis of these conclusions will accompany the main report."

"The situation with regard to La Colle Falls on the North Branch of the river is similar, but the argument is more definitely adverse to development."

Hydro-Electric Power Possibilities.

A summary of the facts concerning the economic possibility of utilising the rivers of Saskatchewan as sources of energy for the more thickly populated areas of the Province appears in the preliminary report, quoted above. They are not encouraging, the argument is further developed hereinunder.

There are no large valuable natural water power sites in Saskatchewan south of the Churchill River. The small sites are of no value for service to the larger load centres. Churchill River sites are too distant for economical delivery at or south of Saskatoon.

Power 'Heads' can be created on the Saskatchewan River to dimensions measured by the safe height of the necessary dam. The cost per kilowatt of winter capacity is necessarily very high since the major portion of the capital required would be expended upon the dam, the river bank and floor protection and the power house structure. The cost per kilowatt of summer capacity (which would be useful during six months only) would be relatively lower per unit, but of the generating plant installed for such possible usefulness, only a small fraction would be in service during winter periods because of the low river discharge.

Floods of huge dimension must be safely carried past any such works. At times of peak summer floods the operating head would be reduced greatly because of high 'tail water.'

The storage of water for purposes of equalising winter and summer flows is impossible. Such storage as is possible is in the mountain and foothill district and is extremely moderate in dimension, and expensive.

Winter stream flows will permit generation of only from 12,000 Kw. to 20,000 Kw. at The Forks.

The Saskatchewan River as a Source of Energy

We have prepared a considerable range of studies of the possibilities for deriving energy from the North Saskatchewan River at La Colle Falls, also from the combined flow of the North and South Forks of the Saskatchewan River at their junction (referred to hereinunder as "The Forks").

The following tables, derived from records of the Water Power Branch of the Department of the Interior, have been developed and subjoin this discussion.

(a) Average Flow during Two Lowest Seven-day Periods in in each Year, 1914-1925 . . Table No. 21.

(b) Average Flow during Lowest Week in Lowest Month of the Six Highest Months in each Year, 1914-1926. . . . . Table No. 22.

These statistics (a) and (b) are bases of stream power ratings used by the U.S.A. Federal Departments.

(c) Average Flow during Four Winter Months of each Year, 1913-1926 . . . . Table No. 23.

(d) Date and Dimension of Lowest and Highest Flows in each Year, 1913-1926 Table No. 24.

(e) Number of Days in each Year during which the Flow of the combined Streams at The Forks is less than each of a series of Dimensions, also the number of days in which the flow exceeds 15,000 and 20,000 cubic feet of water per second respectively, Tables Nos. 25-F-1 and 25-F-2.

(f) The Average of the 1912 to 1925 Mean Monthly Discharge, Table No. 26.

Flow of Saskatchewan River.

Table No 21.

Average Discharge of Two Lowest Seven Day Periods in Each Year (Sec. Ft)

Year	South Saskatchewan River at Saskatoon		North Saskatchewan River at Prince Albert		Saskatchewan River at The Forks	
	Date	Average	Date	Average	Date	Average
1914	Feb 17-23	1923 7	Jan 14–20	947 7	Feb 21-27	3085
	Dec 21-27	1688 6	Dec 25–31	1194 3	Dec 25–31	2883
1915	Feb 4 10	2178 6	Jan 26–Feb 1	1564 3	Jan 27 Feb 2	4264
	Dec 24–30	2800 0	Dec 25–31	1819 1	Jan 31 Feb. 5	3821
1916	Feb 4 10	1970 0	Feb 11 17	1048 6	Feb 12–18	3106
	Dec 25–31	3981 3	Dec 25–31	2525 7	Feb. 2 8	3060
1917	Mar 21-27	2415 7	Mar 20-26	1648 6	Dec 23-29	2768
	Dec 22–28	1407 6	Dec 22-28	1118 3	Dec 25–31	26.8
1918	Jan 1–7	1764 8	Jan 1–7	1641 4	Jan 2–8	3195
	Mar 5 11	2097 1	Feb 21 27	1467 7	Mar 9 15	3647
1919	Jan 1 7	1600 0	Mar 18–24	811 4	Mar 19-25	2507
	Dec 17-23	1156 4	Dec 16–22	1200 4	Dec. 21-27	2231
1920	Feb 8 14	1598 7	Feb. 13–19	1127 3	Feb 14–20	2787
	Dec 24–30	795 6			Feb 12-18	2752
1921	Feb 22–28	1552 1	Jan. 5–11	758 6	Jan 6–12	1978
	Dec 10-16	1718 6	Mar 9 15	758 6	Dec 28–Jan 3	1725
1922	Feb. 26–Mar 4	1417 1	Jan 26–Feb 1	668 7	Mar 2 8	2348
	Dec. 18–24	1095 7	Dec 25–31	520 9	Dec 22–28	1666
1923	Mar 1–7	1.05 7	Jan 1–7	471 9	Jan 2–8	1759
			Mar 8 14	741 6	Mar 8 1.	1883
1924	Jan 7-13	1460 0	Jan 18–24	762 9	Jan 11-17	2388
	Dec 17-23	1610 0	Dec 19–25	1521 4	Jan. 19–25	2333
1925	Jan 1–7	1764 3	Feb. 16–22	1240 0	Jan. 5–12	3261
	Dec 1 7	3190 0	Dec 25–31	1858 7	Feb. 17-23	3494

Table No. 22.

Flow of Saskatchewan River

Average for Lowest Week in Lowest Month of Six Highest Months in each Year

North Saskatchewan River at Prince Albert

1914	Sept 28—Oct 4	6396 4 ft. sec.
1915	May 8—May 14	5005 7 ft. sec.
1916	May 24—May 30	6397 1 ft. sec.
1917	Sept. 21—Sept. 27	8351 7 ft. sec.
1918	May 30—June 6	7729 1 ft. sec.
1919	May 12—May 18	4346 0 ft. sec.
1920	Sept 23—Sept 29	6254 0 ft. sec.
1921	Oct 5—Oct. 11	3700 0 ft. sec.
1922	Oct. 9—Oct. 15	5755 6 ft. sec.
1923	May 15—May 21	3760 0 ft. sec.
1924	May 1—May 7	6718 6 ft. sec.
1925	May 17—May 23	7371 6 ft. sec.
1926	June 2—June 8	5401 4 ft. sec.

South Saskatchewan River at Saskatoon

1914	Sept 25—Oct 1	7129 7 ft. sec.
1915	Sept 24—Sept. 30	12690 0 ft. sec.
1916	May 2—May 8	9126 4 ft. sec.
1917	Oct 2—Oct 8	6660 0 ft. sec.
1918	Sept. 24—Sept 30	5375 0 ft. sec.
1919	Sept 24—Sept 30	5488 1 ft. sec.
1920	April 12—April 18	5000 0 ft. sec.
1921	Sept 24—Sept. 30	3830 9 ft. sec.
1922	Sept. 25—Oct. 1	4354 6 ft. sec.
1923	May 4—May 10	8071 4 ft. sec.
1924	April 30—May 6	5681 4 ft. sec.
1925	May 10—May 16	10700 0 ft. sec.
1926	April 5—April 11	6251 4 ft. sec.

Saskatchewan River at The Forks

1914	Sept 28—Oct 4	14023 ft. sec.
1915	May 8—May 14	14733 ft. sec.
1916	May 4—May 10	16898 ft. sec.
1917	Oct 4—Oct. 10	13808 ft. sec.
1918	Sept 26—Oct 2	12966 ft. sec.
1919	May 12—May 18	14246 ft. sec.
1920	April 14—April 20	7019 ft. sec.
1921	Oct 5—Oct 11	6533 ft. sec.
1922	Oct 9—Oct 15	8833 ft. sec.
1923	May 15—May 21	103.3 ft. sec.
1924	May 2—May 8	12600 ft. sec.
1925	May 17—May 23	18927 ft. sec.
1926	April 7—April 13	9368 ft. sec.

Table No 23.

Flow of Saskatchewan River.

Mean for

December, January, February and March.

	Prince Albert	Saskatoon	The Forks
1913	1,742 3	1,890 0	3,632
1914	1,381 5	2,905 5	4,287
1915.	1.913 7	3,081 5	4,995
1916.	1,528 2	6,057 0	7,585
1917	2,286 0	3,590 7	5,877
1918	1,680 7	3,009 8	4,690
1919	1,174 0	2,074 5	3,249
1920	1.403 0	2,025 2	3,428
1921	1,137 .5	2,010 7	3,157
1922	1,014 0	1,710 7	2,725
1923	833 5	1,440 0	2,274
1924	1,755 0	2,200 0	3,955
1925	1,507 5	2,592 5	4,100
1926	1,822 5	4,472 5	6,295

Flow of Saskatchewan River.

Table No 24

Lowest and Highest Average Daily Flow for Each Year

Year	S. Saskatchewan at Saskatoon			N Saskatchewan at Prince Albert			Saskatchewan River at The Forks		
	Date	Lowest	Highest	Date	Lowest	Highest	Date	Lowest	Highest
1913	Jan 10	1,130		Jan 24	1,375		Jan 25	2,525	
	July 6		42,710	Aug. 21		35,665	July 8		71,940
1914	Dec. 25	1,580		Jan 17	920		Dec 28	2,630	
	June 26		35,128	June 14		63,290	June 14		86,360
1915	Feb 17	2,150		Jan 1	1,280		Feb 21	3,710	
	July 2		111,012	July 2		186,546	July 2 and 3		297,558
1916	Jan 30	1,900		Jan 22	1,080		Feb. 3	3,020	
	June 26		39,800	June 26		53,200	June 28		143,000
1917	Dec 25	1,410		Dec. 28	1,038		Dec 28	2,478	
	June 10		66,268	May 31		43,600	June 12		101,832
1918	Dec 31	1,500		Dec 30	1,110		Dec 31	2,600	
	June 20		38,588	June 22		32,665	June 24		71,263
1919	Dec 17	1,140		Dec 21	900		Dec 22	2,080	
	June 6		35,562	Aug 14		18,612	June 9		49,292
1920	Dec. 28	770		Dec. 30	850		Dec. 31	1,720	
	May 14		62,180	May 14		55,280	May 17		105,580
1921	Jan 1	870		Jan 3	680		Jan 4	1,550	
	June 17		35,000	June 16		24,256	June 20		56,008
1922	Jan 6	1,320		Jan 26	650		Jan 10	2,260	
	June 18		37,800	Aug 25		24,060	May 15		73,712
1923	Feb. 21	1,090		Jan 1	428		Jan. 2	1,688	
	June 29		86,800	June 20		52,700	July 1		133,800
1924	Jan. 10	1,410		Jan. 24	760		Jan 5	1,940	
	July 10		26,108	June 17		21,600	July 14		37,700
1925	Jan 2	1,490		Jan 10	1,260		Jan. 14	2,840	
	May 31		35,800	April 14		30,300	June 3		53,300
1926	Jan 23	2,490		Jan 28	1,060		Jan. 27	3,580	
	Sept 19		40,600	Sept 9		47,700	Sept. 22		66,900

Table No 25-F-1

Flow of Saskatchewan River

Forks Station, Oct 1—Sept 30

Number of Days in each Year in which the flow is below

c.f.s	1913-14	1914-15	1915-16	1916-17	1917-18	1918-19	1919-20	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26
1,000													
2,000								7		54			
3,000					12	50	28	69	86	114	26	2	
4,000	58	16	36	3	30	116	132	89	27	145	61	101	42
5,000	101	78	65	36	93	136	150	132	136	148	110	122	60
7,000	129	108	87	105	119	147	165	144	183	160	151	144	118
10,000	159	136	111	149	151	158	195	192	187	196	168	162	137
12,000	170	139	112	150	168	183	210	207	188	202	182	177	154
15,000	186	183	127	151	198	233	224	218	201	219	214	181	184
20,000	246	202	176	176	266	303	229	234	230	254	247	191	291

Table No 25-F-2.

Flow of Saskatchewan River

Forks Station, Oct. 1—Sept. 30.

Number of Days in each Year in which the Flow.

Year	is above 15,000 c.f.s	is above 20,000 c.f.s.	is above 16,000 c.f.s
1913-14	179	120	150
1914-15	182	163	171
1915-16	239	190	230
1916-17	214	190	211
1917-18	167	99	164
1918-19	132	62	138
1919-20	142	167	141
1920-21	147	131	144
1921-22	164	135	156
1922-23	146	111	135
1923-24	152	119	145
1924-25	184	171	175
1925-26	181	74	137

Table No. 26.

AVERAGE OF MEAN MONTHLY DISCHARGE OF SASKATCHEWAN RIVER AT SASKATOON, PRINCE ALBERT AND THE FORKS—1912 TO 1925

		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	Average Mean at Saskatoon	Average Mean at Prince Albert	Average Mean at The Forks
January	S.	1,886	1,247	2,702	3,379	2,646	3,657	2,562	1,882	2,062	1,439	1,604	1,620	1,680	2,160	2,142		
	N	1,605	1,663	1,221	1,760	1,422	2,199	1,879	1,202	1,460	955	805	890	1,020	1,510		1,395	3,537
February	S.	3,297	1,981	2,130	3,345	2,488	3,142	3,133	2,494	1,924	1,625	1,458	1,220	2,090	2,290	2,170		
	N	1,584	1,588	1,191	1,655	1,160	2,015	1,670	1,226	1,255	1,121	781	942	1,620	1,370		1,365	3,525
March	S.	2,304	2,432	3,038	3,318	15,342	2,746	4,335	1,925	2,503	2,934	1,981	1,450	2,450	3,450	3,900		
	N	1,579	1,981	1,295	1,707	1,283	1,781	1,729	871	1,263	988	1,013	835	1,750	1,270		1,385	5,285
April	S.	14,512	16,862	8,319	13,472	19,894	16,694	13,252	7,619	15,615	11,836	11,887	6,820	8,040	24,600	17,200		
	N	9,022	16,330	4,350	9,046	7,425	8,704	8,701	6,457	3,790	14,205	5,147	3,470	3,870	17,900		8,390	25,590
May	S	14,737	11,937	13,876	19,818	13,474	23,308	12,920	9,424	25,032	12,902	15,370	8,430	11,800	16,000	15,700		
	N	11,250	12,149	13,235	7,003	9,368	26,370	7,636	5,449	31,559	15,428	11,220	6,190	11,900	10,800		12,900	28,000
June	S.	28,204	32,426	26,375	36,144	61,612	57,662	23,090	19,398	25,394	26,022	26,224	36,300	20,700	26,900	32,200		
	N	14,864	19,042	30,347	25,023	24,123	30,195	15,766	7,625	24,443	17,087	14,589	28,300	13,200	16,900		19,090	52,180
July	S.	33,602	24,232	22,094	60,366	58,900	30,232	14,847	10,312	31,464	15,061	13,757	32,000	18,600	17,600	27,200		
	N	35,301	26,185	29,456	60,224	32,018	22,427	16,908	11,643	29,250	16,797	14,207	20,300	16,000	17,300		25,600	52,800
August	S.	23,681	14,854	9,762	33,704	26,707	11,968	8,739	9,638	13,526	8,126	7,871	13,900	13,400	9,160	14,620		
	N.	30,044	25,096	14,550	28,129	25,090	14,326	12,424	14,967	17,731	14,322	15,761	26,600	15,600	22,700		19,350	33,970

September.	S.	16,359	9,143	7,945	16,257	29,721	8,914	8,143	6,140	5,804	4,273	5,786	9,310	7,670	8,820	10,150		
	N	22,277	14,576	10,304	14,990	23,017	10,127	8,167	11,249	8,601	7,342	11,230	13,600	11,500	18,000		18,230	23,380
October	S.	9,293	7,909	10,315	12,714	14,071	5,458	5,140	3,206	4,609	3,016	3,590	5,610	5,020		6,900		
	N	10,024	7,114	7 763	7,653	11,540	6,920	6,362	4,432	5,293	3,530	3,700	6,960	5,210			6,800	13,700
November	S.	7,414	6,079	8,151	6,118	8,067	4,582	4,239	1,688	2,554	2,793	2,460	3,310	2,960		4,660		
	N	4,915	3,022	3,738	3,898	6,134	4,031	2,755	2,072	3,296	2,226	2,550	3,380	2,320			3,420	8,080
December	S.	2,300	3,752	3,204	3,855	4,952	2,096	2,097	1,612	2,031	1,500	1,470	2,680	2,476		2.710		
	N	2,315	1,519	2,533	2,238	3,148	1,446	1.403	1,514	1,506	1,397	767	2 730	1,386			1.905	4.645

The following group of *Charts and Diagrams* sets out much interesting and instructive information regarding the flow of the North Saskatchewan River at La Colle Falls and the discharge of the combined North and South Rivers in one stream at The Forks. Estimates of horsepower at these two points are based on a mean twenty-one foot head at the site of the dam begun in 1912 by the City of Prince Albert, and a mean head of forty-two feet at a dam which can be erected across the combined stream within a mile below The Forks.

(g) This diagram (L 5) (see appended photostat) shows the Mean Monthly Flow of the North Saskatchewan River at La Colle Falls (Prince Albert) for the two years 1913 and 1914.

(h) This is a curve (F 3) showing the Mean Number of days in the year during which the flow is less than certain specified dimensions up to 20,000 cubic feet per second below The Forks averaged for the years 1913 to 1926. A discharge of 20,000 c.f.s. is equivalent to an output of power of 80,000 horsepower (60,000 kilowatts) at generator terminals under a head (or difference of level between headwater and tail water levels) of 45 feet.

This curve clearly indicates the very definite limits of commercial value of the Saskatchewan River as a source of energy. For instance, during the average year the flow is less than 4,000 c.f.s. (17,000 H.P. at 45 ft. head) for periods totalling 72 days, it is less than 16,000 c.f.s. (64,000 H.P. or 48,000 Kw. at 45 ft. head) for periods totalling 208 days.

(j) This chart (Diagram F 2) sets out similar information concerning the power and energy possibilities at The Forks for 1915 and 1919, years of unusually high and of unusually low river flow. As example, the curves show that with 45 feet of head there could have been derived 50,000 Kw. during 31 per cent. of the season 1919, and during 62 per cent of the days of 1915, similarly they show that for 61% of the days of 1919 the possible power output would have exceeded 15,000 Kw. and conversely that for 39 per cent. of the time the output could not have been greater than 15,000 Kw. and for 30 per cent. of the time not more than 12,000 Kw. could have been derived from a 50,000 Kw. power plant at The Forks under 45 feet head.

For over 50 per cent. of the 1919 an equipment of 50,000 Kw. of generating capacity could have been utilised to the extent of 60 per cent. of its capacity or to greater extents up to the full limit of its output.

A discussion of the possible value of the larger flows to a general transmission scheme follows later in this report.

(k) The profile of the Saskatchewan River is very flat, there are no falls, no really important rapids, and only at intervals along the stream do stretches of unusually swift

water appear "Head" must be created by erection of a dam at any site chosen for development of power, it is equivalent to the difference in elevation between Head Water Level and Tail Water Level. The Head Water Level can be controlled to an approximately uniform elevation, water not required for power generation being wasted through sluices. The Tail Water Level cannot be so controlled, and will correspond to the depth in the channel necessary for passage of the river flow away from the dam and through the natural river channel downstream from the dam. The "Head" thus diminishes with increased flow.

Curve K 1 shows the diminution of available power head at La Colle if the dam be completed across the North Saskatchewan River. Thus with flows of less than 20,000 c f s the head would be in excess of 19 feet, with flood flow of 180,000 c f s (as experienced in July of 1915) the head at the dam would fall to 3 5 feet.

In the studies which follow the turbines for La Colle are assumed to be designed for operating head of 21 feet, available throughout the major regimen of the stream. The output to be had from such turbines is not proportional to the head. Thus, from the four units suggested hereinunder as a basis of valuation of La Colle Falls an output of 10,800 Kw can be had at 21 feet of head, when the operating head falls to 10 feet due to flood conditions—provided the turbine speed is maintained—the total output would fall to 5,000 Kw.

Curve F 1 shows Variation of Head at The Forks, and The Station Output available under different heads, from an installation of 50,000 Kw. Discussion would be parallel to that hereinunder concerning Curve L 1.

Graph M is a record of the average stream flow in each month from 1912 to 1935. The *broken* line shows the flow passing Prince Albert (La Colle) in the North Saskatchewan, the *full* line shows the flow of the combined North and South rivers at The Forks.

During nearly continuous summer periods of six months of each year (except during 1919) a flow of 8,000 c f s. at La Colle could be utilised. This corresponds to a 20 per cent overload on 10,000 Kw of capacity under a head of 21 feet. For shorter periods of each year a larger output of power could be obtained but a six months' output from such an investment is surely sufficiently unattractive for investment of the relatively large sums required for completion of the dam and for the transmission line of one hundred miles (100 miles), necessary to make contact with the system of circuits which would connect the three principal Saskatchewan cities.

Graph N 2 shows the *Daily Flow* and the Theoretic horsepower limit at The Forks during the record high flows of 1915. Graph N 1 shows the same features for 1919, the year of record low flows on the Saskatchewan River.

Graph N 1 shows also the possible kilowatt-hours of energy derivable from 50,000 Kw of generating capacity at The Forks during the year of low flow

It will be noted that but a small fraction of the output is derivable during the winter months—about nineteen per cent. as against eighty-one per cent. during the summer months.

The same figures are set out in the subjoined Table No 27, possible output of generators, based on mean monthly flow

Table No 27

WATER POWER SCHEME AT FORKS OF SASKATCHEWAN RIVER

Theoretic Output from Generators Based on Mean Monthly Flow, 1912-1925

	Head (ft.)	Flow (c.f.s.)	Kw	Kwh
January	49.4	3,587	11,800	8,500,000
February	49.4	3,525	11,750	8,400,000
March	49.0	5,285	50,000	12,600,000
April	44.7	25,590	50,000	36,000,000
May	44.6	28,600	50,000	36,000,000
June	42.2	52,190	50,000	36,000,000
July	42.1	52,800	50,000	36,000,000
August	44.0	33,970	50,000	36,000,000
September	44.8	23,380	50,000	36,000,000
October	46.5	13,700	43,200	31,100,000
November	47.8	8,080	26,200	18,900,000
December	49.2	4,615	14,450	10,500,000
Total for average year				306,000,000
Total for six summer months				216,000,000

The output will be less because of the reduction in operating head throughout the days of maximum flood. Further the energy must be absorbed by the market uniformly throughout the twenty-four hours of each summer day since at the Forks is relatively small local water pondage.

Table No 28.

ESTIMATE OF SUMMER KWH DEMANDS ON TRANSMISSION SYSTEM, INCLUDING BATTLEFORD AND KAMSACK BRANCHES.

From Established Load Curve Projected from 1927

1927 218,650 Kwh for Thursday, June 23, 1927
1931 320,000 Kwh for Thursday, at corresponding date
1936 515,000 Kwh for Thursday at corresponding date

April to September . . . . . 6 months.

183 days, of which 26 are Sundays,
26 are Wednesdays,
26 are Saturdays,
with reduced demands.

The average Daily Consumption may be taken at not over 80 per cent of the above consumption

Thus: 1927	175,000 Kwh.
1931	256,000 Kwh.
1936	412,000 Kwh.
1941	664,000 Kwh.
1946	1,070,000 Kwh.

and Six Months Consumption.

1931	47,000,000 Kwh.
1936	75,000,000 Kwh.
1941	121,560,000 Kwh.
1946	196,000,000 Kwh.

Compare Possible output of Forks Water Power Station during summer months with 50,000 Kw maximum capacity—216,000,000 Kwh.

During the winter months the demands for electrical energy by the group of cities on a central Saskatchewan transmission circuit will be much greater than during summer months.

Curve "R" shows the hourly variation of joint load on the cities of Regina, Moose Jaw and Saskatoon and on towns and villages, on three branch lines—to the Battlefords, to Prince Albert and towards Kamsack. Records of December 23, 1926 are shown; a similar curve has been projected for the corresponding day of 1930, and of 1935. The 1935 peak for that day would be 47 200 Kw and the energy demand is estimated at 683,250 Kwh. (Note.—The season peak of demand would not necessarily be that shown.)

Curve "S" shows the corresponding facts for June 23, 1926, and shows daily load curves for the corresponding date in 1930 and 1935. It will be noted that the summer day peak of demand (32 100 Kw.) and the summer energy requirement (515,000 Kwh.) are both lower than the estimated peak and energy requirement for the winter day.

Possible Utilisation of "Forks" Power

On the subjoined estimate of summer Kwh. requirements by the transmission system is set out a computation which shows that the energy which can be produced at The Forks during six months from the average summer stream flow certainly could not be absorbed by the system before 1946, it could be absorbed during that year in which the *minimum* summer day's demand by the system reaches fifty thousand kilowatts.

The summer day's demand by the system, assuming the annual increment as ten per cent. (10%) would be,

	Peak	Minimum
In 1936	30,000 Kw.	10,000 Kw.
In 1941	48,000 Kw.	15,000 Kw.
In 1946	72,000 Kw.	23,000 Kw.

It will thus be seen that, if The Forks 50,000 Kw. station were built, it could furnish all kilowatt-hour requirements during summer months until 1941, its capacity until that date would be fully utilised only at peak hours of the summer day, it would not be called upon for more than 150,000,000 Kwh. until later than 1941.

After about 1950 The Forks station could be operated at full capacity during nearly every summer day, and for nearly every hour of the day and so regularly as water flow available would permit. The peaks of daily demand must be provided from some steam-electric station which would furnish all kilowatt-hours required during those portions of the day when the load exceeds 50,000 Kw. This steam-electric station must be large enough to furnish all energy required during the winters.

The applicability of the theorem of utilisation of any water power scheme as a source of energy depends upon whether kilowatt-hours from such a source can be delivered to the centre of gravity of the load at sufficiently low cost per kilowatt-hour. This phase of the problem is discussed in the preliminary report. It has been shown that a kilowatt-hour from a water power source must be generated and transmitted for that fraction of a cent which represents *the bare cost of the necessary fuel* plus a very small share of steam station operating costs.

Water Power Station Studies:

Two studies have been completed: one based on completion of the works at La Colle Falls on the North Saskatchewan begun in 1911 by the City of Prince Albert, and one based on control of the joint flow of the North and South Saskatchewan Rivers at a point immediately below The Forks. The studies of stream flow and of power capacity set out herein elsewhere show clearly that at La Colle Falls it is impracticable to count on sufficient water, even during the summer months, to serve a station of large capacity. The studies of the joint flow at The Forks show that the reasonable upper limit of station capacity is around 50,000 Kw. (See graphs with this report)

La Colle

The fact that one-half the stream channel is closed with a dam of ambursen type (hollow reinforced concrete) limits the elevation to which the headwaters of any power plant can be raised. Not much advantage would accrue to carrying out the original plans for a canal in the north bench and not much value could be had from moneys there already expended. The plan chosen for completion therefore proposes closing the northerly open section of river channel with a pier structure with sluices of full depth to pass flood waters, and with a power house structure adjacent to the north shore. A dyke of earth built upon the bench would tie the power house to high land to the northwest. Our computations show that flood flows can be safely passed through the sluices as designed, in combination with spill over the present dam, and through the lock structure as built. At extreme flood flows the head upon the turbines would disappear because of high tail water, but the plant and works would be safe.

The power house would be equipped with four units of three thousand horsepower (3,000 H.P.) each, direct connected to vertical shaft generators of 2,500 Kw. operating at 6,600 volts and 100 r.p.m.

At times of high river discharge the 'draft' head will be partially maintained by passing flood waters through the building and discharging them over a weir passing the mouths of the draft tubes.

A peak load of about eleven thousand kilowatts could be carried for part of each summer, manifestly sufficient for only a portion of the joint load on the system, a winter capacity in excess of fifteen hundred kilowatts could not be depended upon. The proposition is exceedingly unattractive for the purpose and is not recommended as desirable for any present or future stage of load development except and unless The Forks scheme be ever proceeded with. La Colle could feed a few million kilowatt-hours into a transmission line passing by the site, even then at doubtful economy.

Drawings L.1 and L.2 are submitted herewith showing how it is possible to close the stream channel and to provide for power production. Drawing L.3 shows an appropriate transformer station.

The Forks

The elevation of head water surface can be controlled if emergency passages of sufficient capacity be provided for flood water flows in excess of the turbine requirements. The elevation of tailwater is uncontrollable and depends at any site upon the dimension of the river flow, the available width of channel and the velocity with which the flood waters may pass down stream from the dam.

Careful computations, based upon many records of Saskatchewan River velocities, have been made and Curve K.1 is submitted showing the probable elevations of tailwater surface and the approximate power operating "head" which would be possible under the complete range of river discharges.

The design of dam is simple, requiring the construction of a wide low 'sill' with reinforced concrete apron, upon which sill heavy piers separate thirty-foot openings, closed and controlled by sectional steel gates. The drawings F.4 and F.5 are self-explanatory and provide for a power house adjacent to the right bank of the river. The shore ends would be closed by earthen dykes with concrete core upon deeply driven steel sheet piling to prevent leakage through the benches, which are of glacial materials. Rip-rap of boulders would protect the wetted face of the dykes.

For this report it has been necessary to assume that the soil forming the floor of the river is sufficiently tight and strong to permit raising the headwater level fifty feet above the normal low water plane. (Before decision favorable to construction could be reached very complete exploration of river bed and of river banks at the site would be imperative.) Heavy courses of rip-rap of boulders are required downstream below the 'apron' of the dam, and allowance has been made for some cost for grouting about the steel piling. The sluice gates, divided into sections of weight convenient for handling, would be lifted by means of an overhead

crane travelling on rails laid on a bridge across the pier tops. The design shows a highway bridge alongside the crane runway

The pier and sluice type of dam was chosen because of the necessity of discharging safely past the obstruction a flood flow at least as great as has been experienced (1915—about 285,000 c.f.s.) The width of the river, 1,000 feet at mean water, compels the use of deep sluices for this purpose The need for conserving all possible head at high river flows forces the use of high and heavy piers. The design shown is the result of careful studies of these matters. Our studies of the probable turbulences below the dam indicate the need of a wide 'apron' on the river floor, and of rip-rap beyond The exact width of apron is subject to adjustment if and when construction be undertaken

The power house Drawing F 6. will house five vertical turbine units, each driving an 11,000 Kva., 13,200 volt, 60 cycle, three-phase generator The units would be set on 55 foot centres, and each would carry its own exciter A spare bay at the shore end of the building will permit overhauling of any machine. An electrically operated travelling crane of 100 tons capacity would serve erection and maintenance purposes.

The reasonable maximum summer capacity of a station at The Forks is only about 50,000 Kw This rating can be transmitted over one three-phase cirut at 154,000 volts with best economy The necessary transformer station and switching equipment at The Forks would thus be simple. An outdoor type of transformer station has been estimated upon, equipped with six single phase 13,200-154,000 volt water-cooled units, with necessary single high tension oil switch, low tension switches, and lightning arresters. A spare transformer is provided for in the cost estimates See Drawing F 7 for wiring diagram of this transformer station.

Estimates of Capital Costs of Saskatchewan Powers.

(a) *The Forks*

These are based on the plans prepared for a dam and power house just below The Forks, where discharge from both North and South Rivers is available Since the average six months summer flow permits, a station of 50,000 Kw capacity has been used as the basis Estimates on lesser equipment are also set out

	50,000 Kw	20,000 Kw
Dam, Cofferdams, Power Station, River Bank Protection, Flooding Damages, Operators Houses, etc.	$3,500,000 00	$3,500,000 00
Road Improvement and Maintenance	200,000 00	200,000 00
Generators, Turbines, Governors and Sundry Equipment	2,000,000 00	900,000 00
Engineering and Supervision, Purchasing, etc.	400,000 00	300,000 00
Contingencies, Sundry Services	800,000 00	600,000 00
Total	$6,900,000 00	$5,500,000 00
Per Kw of Capacity for six months use	138 00	275 00

Costs of Energy at Station Bus

	50,000 Kw	20,000 Kw
Interest and Sinking Fund, 7 4%	$ 510,000 00	$ 407,000 00
Contingency Reserve 0 6%	41,000 00	33,000 00
Operating Wages and Superintendence	60,000 00	50,000 00
Maintenance of Sluices, Generating and Sundry Machinery, 2%	37,000 00	16,000 00
Total Annual Costs	$ 648,000 00	$ 506,000 00
Maximum Yearly output possible Kwh , mostly during summer season	300,000,000	150,000,000
Cost per Kwh. if 100% of daily river flow could be utilised	0 216c	0 337c

But on no day will the draft of energy by the transmission system be at peak rate throughout the 24 hours. Even when the summer demand peak reaches 50,000 Kw , say about the year 1941 the *average* consumption would be at the rate of 25,000 Kw to 30,000 Kw and the kilowatt hours during six months would be 110,000,000 During years later than 1941 The Forks plant alone could not supply the peak load, but could supply most of the summer kilowatt hours each year in greater quantity The cost per Kwh in 1941 for energy from The Forks alone would thus be 0 59 cents *But* (1) prior to 1941 the costs would be much higher, because, since the winter demands of the system cannot be met from The Forks a steam electric station must be built in any case, (2) the fixed charges and a portion of the fuel, wages and maintenance costs of the steam station must be carried and would enter into the total average cost of energy supplied to the system *Furthermore*, a transformer station at The Forks, a transmission line of at least 100 miles by direct line (and of 120 miles via Prince Albert) would be required to deliver Forks energy at Saskatoon, the nearest point on the load system.

The Capital Cost of these would be

Transformer station at The Forks, 50,000 Kw	$ 700,000 00
Transmission Line to Saskatoon, 154,000 volts, 105 miles via Direct Route	1,050,000 00
Transformer Station at Saskatoon	550,000 00
	$2,350,000 00

The *Annual Charges* would be

Fixed Charges 8%	$ 188,000 00
Maintenance and Patrol (about)	34,000 00
	$ 222,000 00

On 110,000,000 Kwh. this is equivalent to 0 20 cents per Kwh., making the cost delivered at 110,000 volts at Saskatoon 0 79 cents per Kwh .

Since this cost is *additional* to the unit fixed costs which arise from the necessary steam-electric station, it must be compared with the costs of fuel to be saved by use of hydro-electric energy plus some fraction of the steam station wages which at Elbow would total slightly over 0 40 cents per Kwh only, *i.e.* the savings in steam station operations alone would be less than the cost of energy delivered at Saskatoon.

When the year shall arrive during the summer of which the load system can absorb 220,000,000 Kwh then the costs of delivered energy if drawn from The Forks would be cut in half, to 0 39 cents per Kwh, and the advisability of construction of a large hydro-electric station on the Saskatchewan River may appear

Until that date there can be no excuse for the huge investment.

(Such a situation has now developed in the New Jersey-Philadelphia district, and a huge water power plant is being built at Conowingo on the Susquehanna River to deliver cheap summer kilowatt-hours, to save coal, and to supplement the huge steam-electric stations, themselves capacious enough to serve the load demands at all seasons)

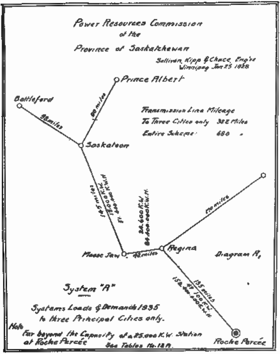
(b) *La Colle.*

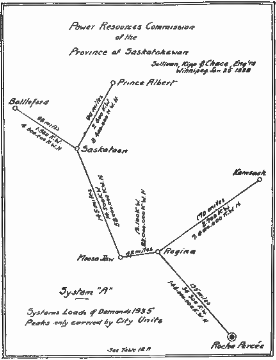
Expenditures at La Colle Falls necessary to complete the river works and to equip a hydro-electric station, and to build a long high-tension transmission line to Saskatoon, are extremely inadvisable for the same reasons. The maximum dependable summer output of such a station, about 12,000 Kw is not sufficient to carry even the present summer peaks on the Regina-Moose Jaw-Saskatoon system Costs of energy delivered at Saskatoon can never be as low as the cost from a central steam-electric station

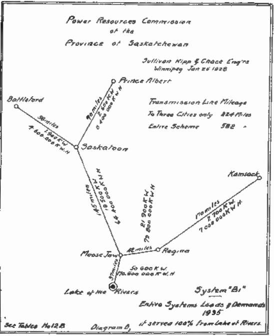
The present winter peak demand of Prince Albert is 900 Kw.; slightly less in the summer It is not yet reasonable to complete La Colle works, and to build 26 miles of transmission line to serve Prince Albert only The winter minimum record flow at La Colle is 850 c.f.s (1914) This would produce 1,200 Kw at 22 feet head Thus as the winter demand grows Prince Albert would be forced to maintain a steam station also

Cost to Complete River Works

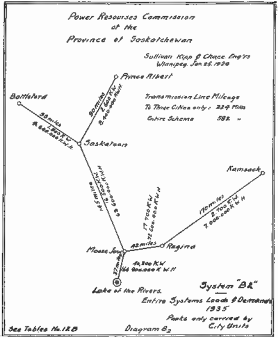
Power House and	
12,000 Kw equipment	$1,000,000 00
5,000 Kw equipment	800,000 00
Transformer Station	80,000 00
Transmission Line	130,000 00
Transformers at Prince Albert	75,000 00
Least Capital for 5,000 Kw	1,085,000 00
or, per Kw of summer capacity	217 00

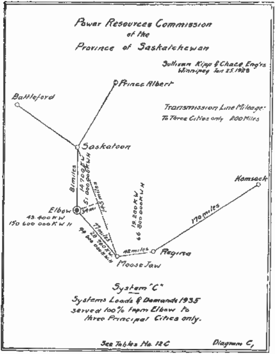

Power Resources Commission
of the
Province of Saskatchewan
Sullivan, Kipp & Chace, Eng'rs
Winnipeg Jan 25 1928
Prince Albert
Battleford
98 miles
Transmission Line Mileage
To Three Cities only 382 Miles
Entire Scheme 680
Saskatoon
145 miles
Moose Jaw
Regina
Diagram A1
System "A"
Systems Loads & Demands 1935
to three Principal Cities only.
Note
Far beyond the Capacity of a 25.000 K.W. Station
at Roche Percée
See Tables No. 12 A.
135 miles
Roche Percée


Power Resources Commission
of the
Province of Saskatchewan
Prince Albert
Saskatoon
Kamsack.
Regina
Moose Jaw
170 miles
135 miles
System "A"
Systems Loads & Demands 1935
Peaks only carried by City Units
Roche Percée



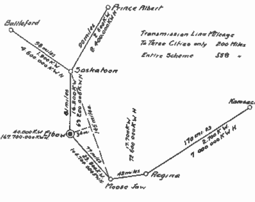
Power Resources Commission
of the
Province of Saskatchewan
Sullivan Kipp & Chace Eng'rs
Winnipeg Jan 26 1928
Prince Albert
Battleford
90 miles
2 600 K W
98 miles
1 900 K W
Transmission Line Mileage
To Three Cities only 224 Miles
Entire Scheme 582 "
Saskatoon
Kamsack
145 miles
19 500 K W
21 900 K W
79 800 000 K W H
110 miles
2 700 K W
7 000 000 K W H
Moose Jaw
42 miles
Regina
37 miles
50 600 K W.
170 600 000 K W. H
Lake of the Rivers
System "B1"
Entire Systems Loads & Demands
1935
if served 100% from Lake of Rivers.
See Tables No 12 B
Diagram B1


Power Resourses Commission
of the
Province of Saskatchewan
Sullivan Kipp & Chace. Eng'rs
Winnipeg. Jan. 26. 1929
Prince Albert
90 miles
Battleford
Transmission Line Mileage
To Three Cities only: 224 Miles
Entire Scheme 582 "
Saskatoon
Kamsack
145 miles
170 miles
Moose Jaw
42 miles
Regina
17 700 K.W
System "B2"
Entire Systems Loads & Demands
1935
Peaks only carried by
City Units
Lake of the Rivers.
See Tables No. 1 & B
Diagram B2


Power Resources Commission
of the
Province of Saskatchewan
Sullivan Kipp & Chace Eng'rs
Winnipeg Jan 25 1928
Transmission Line Mileage:
To Three Cities only 200 Miles
Prince Albert
Battleford
Saskatoon
81 miles
14 700 K.W.
51 000 000 K.W.H
145 miles
34 mi
Elbow
43 400 K W
150 600 000 K W H
77 miles
28 700 K.W.
99 800 000 K.W.H
19 200 K W
66 800 000 K W H
Kamsack
170 miles
42 miles
Regina
Moose Jaw
System "C"
Systems Loads & Demands 1935
served 100% from Elbow to
three Principal Cities only.
See Tables No. 12 C
Diagram C1

Power Resources Commission
of the
Province of Saskatchewan

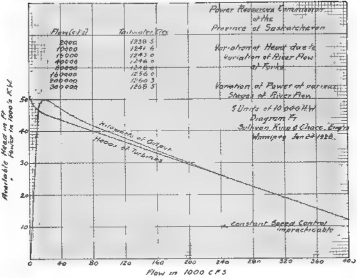
Sullivan Kipp & Chace Eng'rs
Winnipeg Jan 25 1928



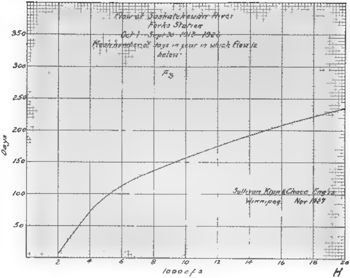
System "C"
Entire Systems Loads & Demands 1935
served from Elbow Station
Peaks carried by City Units

See Table No. 12 C

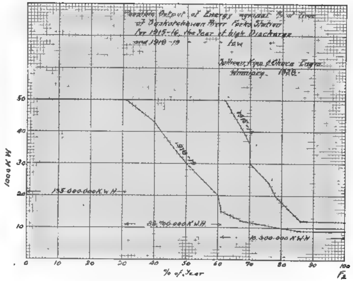
Diagram C$_E$



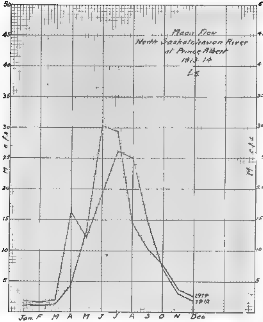
Power Resources Commission of the Province of Saskatchewan
Variation of Head due to variation of River Flow at Forks.
Variation of Power at various Stages of River Flow.
5 Units of 10 000 K.W.
Diagram F1
Sullivan Kinq & Chace, Engrs
Winnipeg Jan 24 1928.
Flow (c.f.s)
Tailwater Elev
2000
10000
15000
40000
80000
160000
200000
300000
1238.5
1241.6
1243.0
1246.0
1256.0
1260.3
1268.5
Kilowatts of Output
Heads of Turbines
Constant Speed Control impracticable
Available Head in Ft
Power in 1000's K.W.
Flow in 1000 CFS



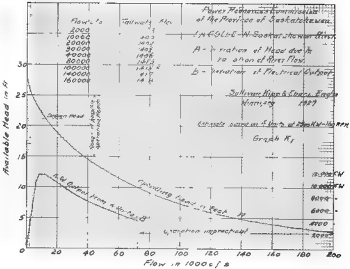
Flow of Saskatchewan River
Forks Station
Oct 1 - Sept 30 1913 - 1926
Mean number of days in year in which flow is below
F3
Sullivan Kipp & Chace Eng'rs
Winnipeg Nov 1927
Days
1000 c f s
H



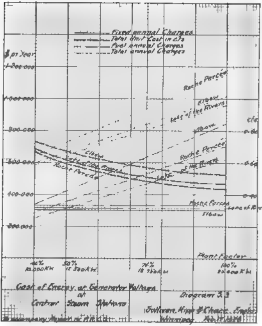
Possible Output of Energy against % of Time
of Saskatchewan River Forks Station
for 1915-16, the Year of high Discharge
and 1918-19 low
Winnipeg. 1928.
1000 K W
% of Year
135.000.000 K.W.H.
F2

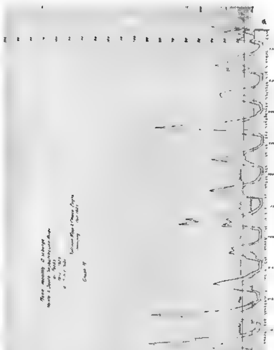

Mean Flow
North Saskatchewan River
at Prince Albert
1913-14
L.S.
Jan. F M A M J J A S O N Dec
1914
1913

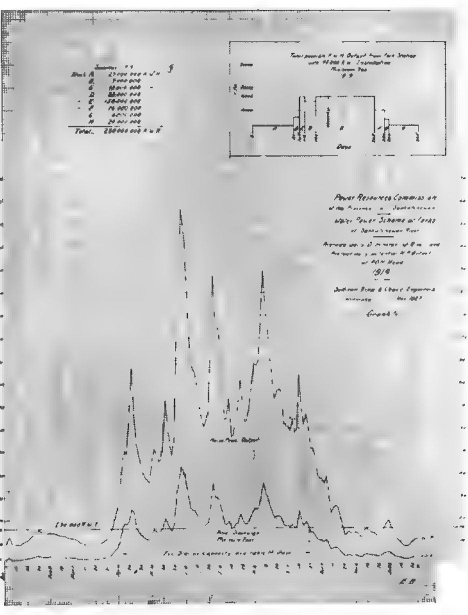
G

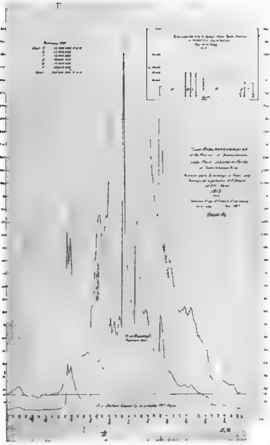


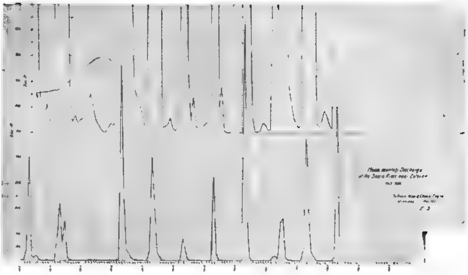
Power Resources Commission
of the Province of Saskatchewan
Graph R1
Available Head in Ft
Flow in 1000 c/s
Design Head
Operating Head in Feet A
Operation impractical
0
5
10
15
20
25
30
20
40
60
80
100
120
140
160
180
200

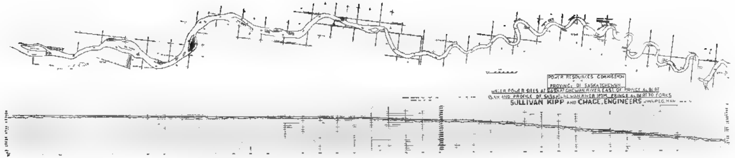

Fixed annual Charges
Total Unit Cost in cts
Fuel annual Charges
Total annual Charges
$ per Year
Roche Percee
Elbow
Lake of the Rivers
Plant Factor
Cost of Energy at Generator Voltage
at
Central Steam Stations
Diagram 3.3

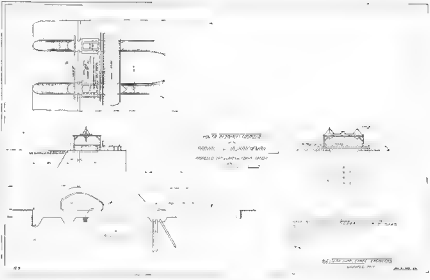


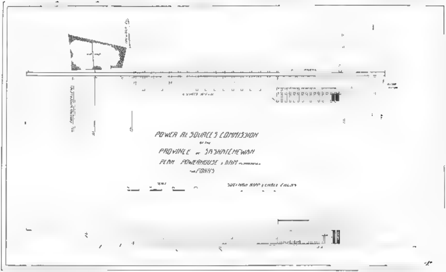

Power Resources Commission
Water Power Scheme at Forks

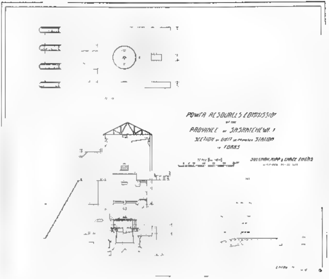


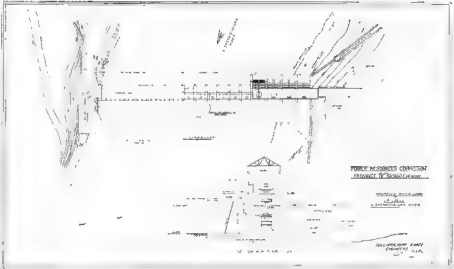


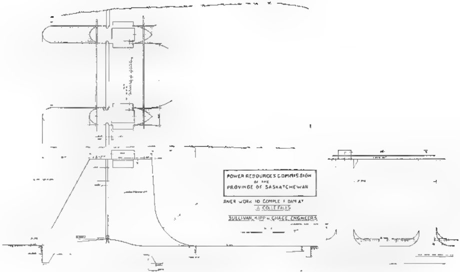

POWER RESOURCES COMMISSION
PROVINCE OF SASKATCHEWAN
SULLIVAN KIPP AND CHACE, ENGINEERS




PROVINCE SASKATCHEWAN
PLAN POWERHOUSE & DAM
FORKS


POWER RESOURCES COMMISSION
PROVINCE SASKATCHEWAN
SECTION UNIT STATION
FORKS

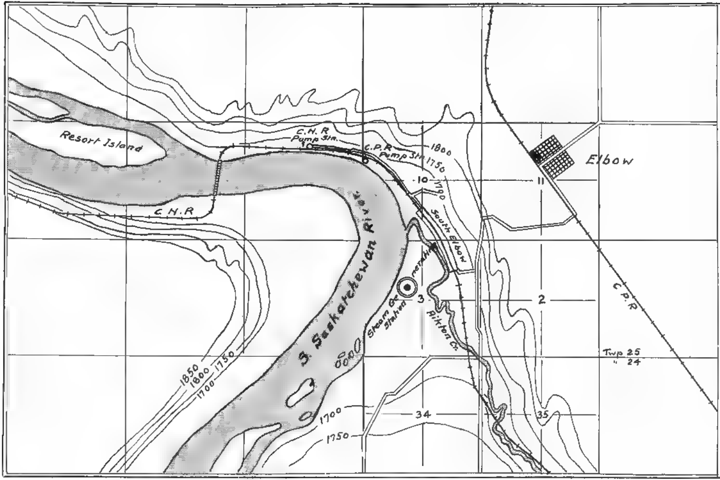

POWER RESOURCES COMMISSION
PROVINCE OF SASKATCHEWAN
N. SASKATCHEWAN RIVER
ENGINEERS


POWER RESOURCES COMMISSION
OF THE
PROVINCE OF SASKATCHEWAN
SULLIVAN, KIPP & CHACE, ENGINEERS

Coal Costs for alternative Steam Stations

Trade name	Owner	Address	Makers		£			876							Remarks
[illegible]	[illegible]		[illegible]		2.50	2.5	8.0	15 100	6.50	$\boxed{24.1}$	6.30	$\boxed{24.0}$	6.30	24.0	[illegible]
[illegible]					2.0	2.0									[illegible]
[illegible]					[illegible]		7.0	[illegible]							[illegible]
[illegible]					[illegible]	9	8.0	5 100							[illegible]
[illegible]					[illegible]		9.0								[illegible]
[illegible]					[illegible]										
[illegible]					[illegible]		[illegible]								[illegible]
[illegible]					[illegible]		7	[illegible]							[illegible]
[illegible]					[illegible]	[illegible]	[illegible]	[illegible]							[illegible]
[illegible]					0.50	7.4	15.0	[illegible]			4.80	$\boxed{25.5}$			[illegible]
[illegible]					[illegible]										[illegible]
[illegible]					[illegible]										[illegible]
[illegible]					0.68	16.5	10.0	[illegible]	4.28	$\boxed{23.7}$	3.60	$\boxed{20.4}$	4.08	[illegible]	[illegible]
[illegible]					0.68	16.5	10.0	[illegible]	4.28	$\boxed{23.7}$	3.60	$\boxed{20.4}$	4.08	[illegible]	[illegible]
[illegible]								[illegible]							
[illegible]						32.0	8.6	6500	1.00	$\boxed{14.7}$					[illegible]
									1.75	$\boxed{12.8}$					
[illegible]					[illegible]										[illegible]
[illegible]					2000 [illegible]	35		6600	2.00	$\boxed{14.7}$					[illegible]

E 4



Sketch showing possible Location of Elbow Steam Station
Power Resources Commission, Saskatchewan.
Scale: 1" = 1/2 Mile
Sullivan, Kipp & Chace, Engr's